A Study of Rates and Factors Influencing

CHANNEL EROSION

along the

DESCHUTES RIVER, WASHINGTON

with Application to
Watershed Management Planning

Report Prepared for:
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Natural Resources Department
Shelton, WA

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April, 1994

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1.0 PURPOSE AND SCOPE OF STUDY

This reports on a study of erosion along the Deschutes River, Washington between its inflow to Capitol Lake at RM 2 and Deschutes Falls at RM 41. The study is part of a project administered by the Squaxin Island Tribe and the Thurston County Conservation District, having the overall goals listed in Table 1-1. Information developed by the project is intended to assist in managing the Deschutes River and Capitol Lake in several planning contexts ***(Table 1-1)***. This study has specific objectives ***(Table 1-1)*** which focus on understanding the natural and human influences on the channel's geomorphology and sediment transport, and applying that understanding to river and watershed management planning.

Several broad planning objectives motivate the project. Those objectives include reducing flooding caused by channel aggradation, reducing loss of land to bank erosion, improving aquatic habitat, and slowing the delivery of sediment to Capitol Lake. The information developed by this study is intended to provide a first step in linking these objectives to a detailed management plan in at least three ways. In general, these are to focus objectives, evaluate potential strategies, and examine conflicts between objectives.

First, a better understanding of channel processes will help to focus objectives and to identify needs for more detailed information and planning decisions. For example, this report provides an initial indication of where and how much channel aggradation might be occurring. This in turn indicates what additional information and planning decisions are needed to make detailed, local assessments of aggradation and its possible role in aggravating flood hazard, and to develop a detailed management strategy.

Second, more understanding of the causes of bank erosion will help to focus on strategies for managing it. For example, different approaches are relevant depending on whether bank erosion along the mainstem is caused by landsliding in the tributary headwaters, mainstem riparian land use, or the river's geologic history. This will in turn point to more detailed information and planning decisions needed for developing a management plan.

Third, better understanding of the river and watershed may indicate whether some objectives are at least partially at odds. For

Table 1-1. Project goals, planning applications, and objectives of this study as defined by Squaxin Island Tribe Natural Resources Department and Thurston County Conservation District.

PROJECT GOALS

- Improve understanding of the geological processes causing bank erosion and channel instability in the Deschutes River;

- Examine patterns of channel disturbance and recovery over time, and the current trends in location and magnitude of effects;

- Determine the geomorphic processes responsible for bank erosion and channel disturbance, and identify characteristics that make particular sites susceptible to disturbance;

- Examine land-use factors contributing to these problems;

- Develop a strategy to alleviate and monitor bank erosion.

MANAGEMENT AND PLANNING APPLICATIONS

- Budd/Deschutes non-point water quality management plan;

- Strategy for implementing bank protection projects;

- Proposal for state Flood Hazard Management planning funding;

- Implementation of the Forest Practices Board "Watershed Analysis" cumulative effects assessment procedure, and

- Strategy to address the effects of bank erosion on beneficial uses in the Deschutes River and Capitol Lake.

STUDY OBJECTIVES

- Conduct an historical analysis of bank erosion, channel widening and channel migration to determine trends in amount and location of these factors over time;

- Evaluate sensitivity of bank materials and stream-side landforms to erosion using information on the soil characteristics of bank materials, the stability of stream-side landforms, hydrologic factors and land use;

- Evaluate historic variation in coarse sediment supply from mass wasting;

- Characterize and evaluate aggraded stream reaches;

- Prepare an integrated analysis of bank erosion in the Deschutes River, including a strategy for reduction of bank erosion.

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example, protecting banks from erosion would reduce loss of land and slow the sediment supply to Capitol Lake, but may conflict with protecting aquatic habitat, because in some reaches bank protection could critically reduce the supply of spawning gravels, isolate off-channel habitat, or change channel morphology or bed material characteristics. Additional information may then be needed to develop detailed strategies that reconcile such conflicts.

Successful planning tends to be iterative. Beginning with initial objectives, the iteration is between identifying information needs and getting information on the one hand versus revising and focusing objectives, choosing strategies, and reconciling conflicts on the other hand. In this context, this study is a first iteration.

This report provides the following information: how sediment and floodwater generated in the forested headwaters affects the mainstem ***(Chapter 3)***; recent and historical rates and locations of mainstem bank erosion ***(Chapter 4)***; causes of mainstem bank erosion ***(Chapter 5)***; and information on channel-bed aggradation between 1977 and 1993 in two sample reaches ***(Chapter 6)***.

Finally ***(Chapter 7)***, this report focuses objectives or indicates approaches for further focusing objectives in light of the information developed in chapters 2-6, outlines possible strategies for achieving objectives, and identifies information needed to develop detailed strategies. Chapter 2 through 6 each conclude with chapter summaries, and an overall study conclusion is found in Section 8. An overview of the study can be gained by reading these chapter summaries along with chapters 7 and 8.

2.0 OVERVIEW OF THE DESCHUTES RIVER BASIN

2.1 Geologic and Topographic Setting

The Deschutes River is a 52 mile-long river that drains 166 mi^2 of the western Cascade Mountain foothills and Puget Lowland of Washington *(Figure 2-1)*. Most (77 percent) of the watershed below RM (river mile) 44 is contained within Thurston County, and the remaining headwaters is in Lewis County *(river miles in this report are from Williams and others 1975)*. The drainage basin drops from a high point of 3870 ft at Cougar Mountain to its mouth at Capitol Lake near sea level *(Figure 2-1)*. Capitol Lake was created in 1950 when a dam was built at the river's mouth at Budd Inlet *(Nelson 1974)*. Tumwater Falls at RM 2 is immediately upstream of Capitol Lake.

The region's glacial geology profoundly influences erosion and sedimentation in the Deschutes River. From its mouth at Capitol Lake to Deschutes Falls at RM 41, the river flows through unconsolidated silt, sand and gravel deposited by the last continental glaciation, which ended about 12,000 yr ago *(Schasse 1987)*. Previous studies have identified bank erosion of these glacial sediments in the reach between Capitol Lake and Deschutes Falls as the dominant source of sediment in the watershed *(Moore and Anderson 1978; Sullivan and others 1987)*.

Above Deschutes Falls at RM 41, the river is generally northerly flowing and has a drainage area of 32.8 mi^2. Total relief of 3,070 ft in the drainage basin upstream of Deschutes Falls (elevation is 800 ft at top of falls) is moderate. Major drainages include Lincoln, Lewis, Buck, West Fork, Ware, Hard, and Mine creeks, which range in area from 0.9 mi^2 in Mine Creek to 4.2 mi^2 in Lincoln Creek. *(Figure 2-1)*.

Upstream of the West Fork confluence at RM 48 the basin is generally competent volcanic rock and has steep, straight slopes focused into narrow, V-shaped valleys. Tributary streams include West For . Mine, Ware, and Hard creeks. In this upper reach, since 1966 int nsive logging and road building have triggered landslides and road surface erosion *(Sullivan and others 1987)*. Some of the coarse sediment is deposited in the low-gradient lower reaches

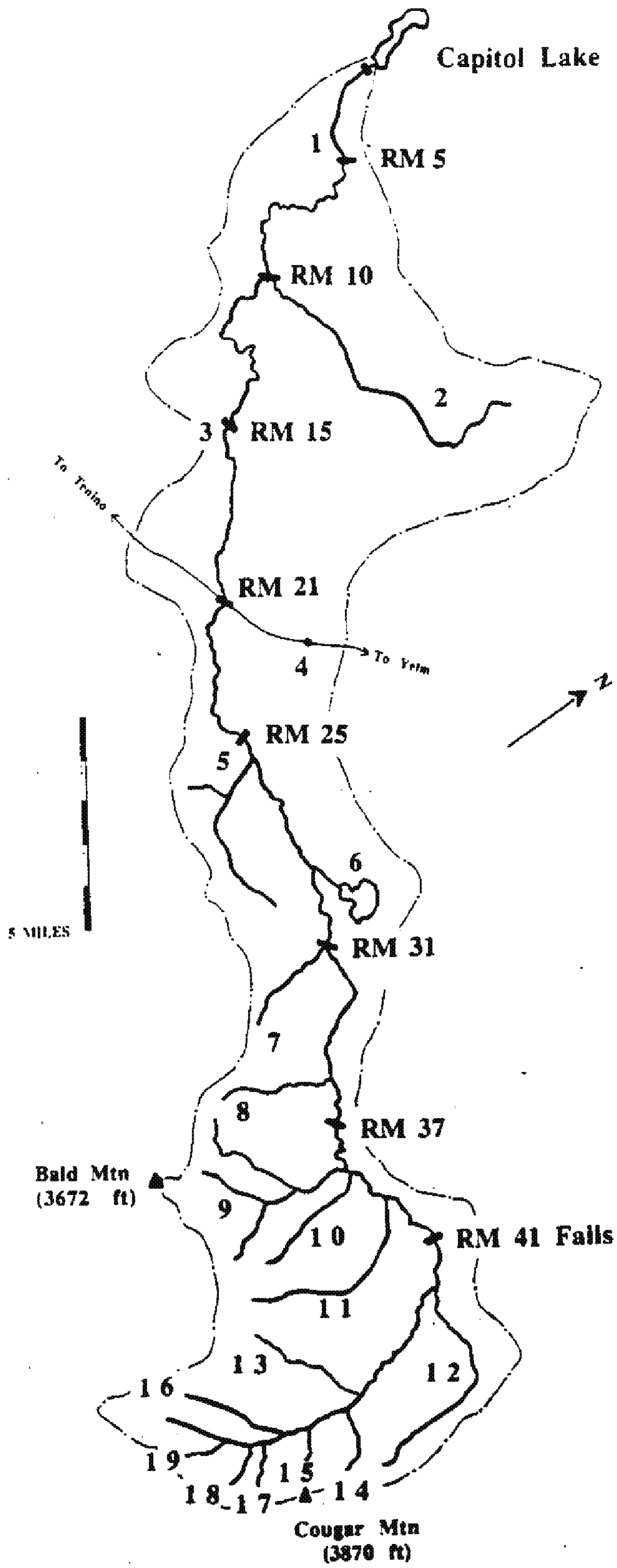

Figure 2-1. Map of the Deschutes River basin. Locations:

1 Henderson Road Bridge
2 Spurgeon Creek
3 Offut Lake
4 Rainier
5 USGS Gage "near Rainier"
6 Lake Lawrence
7 Pipeline Creek
8 Fall Creek
9 Mitchell Creek
10 Huckleberry Creek
11 Thurston Creek
12 Little Deschutes River
13 Lincoln Creek
14 Lewis Creek
15 Buck Creek
16 West Fork Creek
17 Ware Creek
18 Hard Creek
19 Mine Creek

Table 2-1. Locations of stream gages and other landmarks along the Deschutes River. Sources: Nelson *(1974)*, Williams and others *(1975)*, and topographic maps.

	Elevation (ft, msl)	River Mile	Drainage Area (mi^2)
Deschutes River at mouth	0	0	166
Tumwater Falls (at top)	80	2	162
Deschutes River above Spurgeon Cr.	160	10	127
USGS Gage "near Rainier"	370	25	89.8
Deschutes Falls (at top)	800	41	32.8
Deschutes River headwaters	2400	52	0.2

that characterize most tributaries in the forested headwaters, but in the steeper drainages of Ware, Hard, Mine, and Buck creeks landslides travel to their confluence with the Deschutes River.

The geology downstream of the West Fork and above the Falls (RM 48 to RM 41) is predominantly weathered volcanic rocks. Tributary streams include Lewis and Lincoln Creeks. Logging and road building was confined prior to 1966 to the river valley downstream of Buck Creek, and since then has been widespread along the valley sides and in Lewis and Lincoln creeks. While the river valley is wider in this reach than upstream, the channel is largely on or near bedrock, with reaches of alluvial floodplain.

Downsteam of the falls to about RM 34 the river flows alternately through a narrow valley (approximately 100-500 ft in width) bounded by high glacial outwash terraces and broader sections. The river channel gradient declines throughout this reach, causing widespread erosion of the terrace and floodplain banks. The reach also includes left-bank tributaries that drain moderately steep, bedrock terrane. Major tributaries in this reach are Fall, Mitchell, Huckleberry, Johnson, and Thurston creeks ***(Figure 2-1)***. Relief is 1,100 ft in the Johnson Creek watershed, 2,000 ft in Huckleberry Creek, and 2,200 ft in Fall Creek. The drainages of Mitchell and

Thurston creeks, which are bigger than the other three, have relief of about 3,000 ft and head on Bald Mountain (3,627 ft elevation). The drainage networks of Fall, Mitchell, and Huckleberry creek watersheds are incised into weathered volcanic and sedimentary rocks and have steep inner gorges. The lower portions of these drainages (excepting Fall Creek) are less steep than their headwaters and are formed in glacial sediments. Timber harvest began prior to the first available aerial photos in 1941, and has triggered landslides in these drainages, periodically transporting and depositing sediment to these tributaries' low-gradient lower reaches in the last several decades.

The Deschutes River has no significant coarse-sediment-producing tributaries downstream of Fall Creek at RM 35. The outlet of a tributary creek at RM 25.5, which originates at Reichel Lake, is isolated from its headwaters by a lower reach of wetlands and low-gradient (0.002) stream and is not a significant bedload contributor. Spurgeon Creek at RM 10 (drainage area 11 mi^2), the other large tributary downstream of RM 35, drains gently-sloping glacial outwash terrane to the north, and contributes less than 1 percent of the river's total sediment load, according to a previous U.S. Geological Survey study ***(Nelson, 1974)***, and no significant bedload because of a low-gradient wetland in its lower reach. Thus all coarse sediment produced to the river downstream of RM 35 is from mainstem bank erosion.

From RM 34 to RM 29 the river flows through relatively low alluvial banks. This reach has some gravel bar deposition, because the river gradient continues to decline and the river is somewhat mobile laterally. However, migration and erosion rates are low. From RM 29 to RM 16, the river has a relatively constant gradient and except for a moderately mobile reach at RM 20-24, the river is generally stable laterally, and banks are low, ranging between about 5 and 10 ft. Bank erosion overall is not quantitatively large from RM 16 to RM 34 compared to upstream of RM 34 and downstream of RM 16.

Downstream of RM 16 the river again flows between high terraces ranging in height up to 100 ft. The outwash is generally a gravelly sand, but from about RM 10 to Capitol Lake, the outwash includes a silty sand facies. Between the terraces, the river has created an alluvial floodplain of about 400-3,000 ft in width. At some river bends the river undercuts the glacial outwash terraces at the valley sides, thereby continuing the process of valley formation that has been underway since deglaciation about 12,000 yr ago.

2.2 Streamflow

The longest streamflow record is from a gage maintained near the town of Rainier by the U.S. Geological Survey since 1949 at RM 25, roughly at the halfway point of the 52-mile-long river, and below roughly half (89.8 mi^2 or 54 percent of 166 mi^2) of the Deschutes' drainage area ***(Nelson 1974)***. For the 32 years of full annual recording, the average annual flow was 264 cfs. The river has also been gaged near its mouth in Olympia (1946-1964), where the average annual flow was 405 cfs.

Because the river basin has a moderate and low elevation, runoff is dominated by rainfall or by rain augmented by snow melt ***(Brunengo and others 1992)***. Consequently, peak runoff and flood events typically occur in winter and late fall. The largest storm on record at the Rainier gage occurred in January 1990, when the instantaneous peak discharge was 9600 cfs. This 1990 storm event exceeded the previous record high flow from January 1974 of 7780 cfs; the third largest event (7420 cfs) occurred in January 1972, and the fourth largest (5980 cfs) in 1991 ***(Figure 2-2)***.

The 2-yr, 10-yr, 50-yr, and 100-yr floods have been estimated using 1949-1979 records to be 3,400 cfs, 5,800 cfs, 7,500 cfs, and 8,200 cfs, respectively ***(Williams and Pearson 1985)***. The improbability of having within a 42-yr period two 50-yr floods and one flood much larger than the predicted 100-yr event suggests these published estimates which are computed from only 30 yr of data may be significant underestimates.

Flood records prior to 1949 are available only from the Olympia gage, and for only four years prior to the start of recording at the Rainier gage (1946-1949). During this period there were no peak flows exceeding a 5-yr event as calculated for that station from 19 yr of flood data (1946-1964)***(Williams and Pearson 1985)***.

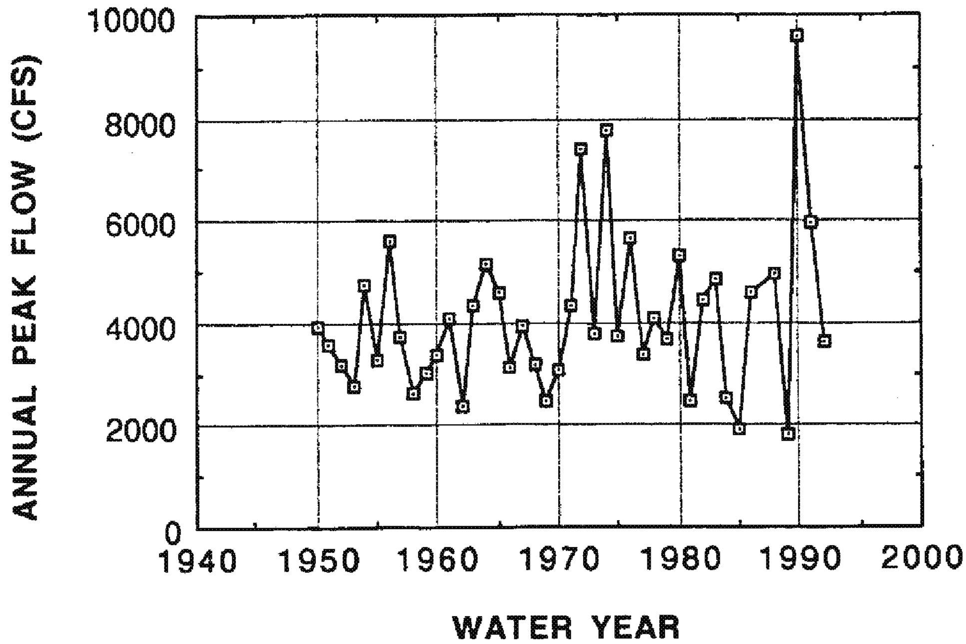

Figure 2-2. Peak annual instantaneous flood discharge, Deschutes River near Rainier, 1950-1992. Gage is located at RM 25, where drainage area is 89.8 mi^2. Data is from U.S. Geological Survey and Sullivan and others *(1987)*.

2.3 Riparian Land Use and Land Cover

As part of this study, land use and vegetation were mapped within the riparian corridor (300 feet to either side of the river) from RM 2 to Deschutes Falls at RM 41. The river banks are dominated by forest cover upstream of about RM 30. Downstream, land cover includes forest, cultivated fields, and housing. In the town of Tumwater from about RM 4 downstream, the riverscape is dominated by an extensive golf course and various urban and industrial uses.

Overall from RM 2 to RM 41 upland-contiguous forest borders about 44 percent of the channel and a vegetative buffer (a band of forest less than 300 ft wide between the river and adjacent landward non-forest cover) is present on 48 percent. The remaining six percent is farmland lacking riparian vegetation (4 percent), lawn (2.1 percent), shrub (1.6 percent), road (0.4 percent) and industrial (0.3 percent). Chapter 5 and Appendix 10-6 provide more detail on riparian conditions.

2.4 Chapter Summary

Previous studies indicate that mainstem erosion of glacial outwash terraces of silt, sand, and gravel dominates sediment production in the Deschutes River basin. This has probably been the case since deglaciation about 12,000 yr ago, when the river began to carve a valley in these deposits. Most of this erosion takes place in RM 2-16 and RM 34-41.

Steep headwater tributary streams generate sediment from landsliding, bank erosion, and road erosion. No tributaries contribute coarse sediment to the mainstem downstream of RM 35. Mainstem bank erosion is the only significant coarse sediment source downstream of RM 35.

Large floods occur in late fall and early winter from rain or rain on snow. The largest peak annual floods since 1946 have occurred, in descending order, in 1990 (1st), 1974 (2nd), 1972 (3rd), 1991 (4th), 1956 (5th), and 1964 (6th).

Riparian vegetation and land use is dominated by a strip of forest less than 300 ft wide (48 percent), upland-contiguous forest (44 percent). Various other land uses make up the remaining 6 percent.

3.0 LANDSLIDING AND SEDIMENT YIELD FROM TRIBUTARIES

3.1 Purpose

The purpose of this section is to estimate how much coarse sediment is contributed to the mainstem study reach (RM 2-RM 41) from tributaries, primarily for the purpose later in the report *(Section 5)* of evaluating whether coarse tributary sediment plays a significant role in causing bank erosion in the study reach. "Tributary" in this report refers to channels tributary to the river's mainstem between RM 2 and RM 41 (the study reach), and also the Deschutes River and its tributaries upstream of RM 41 *(Table 3-1)*.

Coarse sediment from steep, headwater streams under mature forest cover in mountainous western Washington and similar environments is usually generated by landsliding and bank erosion. Forest roads and clearcut logging in most drainage basins substantially increase landlide rates *(for summaries, see Sidle and others 1985; NCASI 1985; PENTEC 1991)*. Bank erosion in mature forests is generally slow, and keeps pace with the gradual, slow, downslope "creep" of soil to streamsides *(Dietrich and others 1982)*. Riparian logging, by physically disturbing streambanks and by cutting trees which then lose rooting strength, can significantly increase bank erosion *(Roberts and Church 1986)*.

This section includes an inventory of landslides that entered streams. For the purpose of this report, the term "landslide" is used in general discussions to include shallow-rapid landslides, debris flows, dam-break floods, and deep-seated failures, although these processes are treated separately in the inventory. This section also identifies reaches that have undergone bank erosion associated with riparian logging at rates significantly more rapid than under mature forest, and also routes sediment from landsliding and tributary bank erosion to the mainstem. Section 5 of this report uses this information to assess the role of tributary bedload in causing bank erosion in the study reach. Finally, this section of the report assesses the contribution of tributary suspended sediment to the river's total load, which could be important for planning how to reduce sediment deposition in Capitol Lake and in other applications.

Table 3-1. River miles of major tributaries to the Deschutes River. Data from Williams and others *(1975)*, Sullivan and others *(1987)*, and topographic maps. Figure 3-1 shows tributary locations.

Drainage or Location	River Mile	Drainage Area (mi^2)
Pipeline Creek	31.0	4.2
Fall Creek	35.3	1.4
Mitchell Creek	38.15	8.8
Huckleberry Creek	38.2	1.8
Johnson Creek	39.1	2.1
Thurston Creek	39.4	4.6
Deschutes River above Deschutes Falls	41.2	32.8
Little Deschutes River	42.5	7.9
Deschutes River above Little Deschutes River	42.5	23.1
Lincoln Creek	46.0	4.2
Lewis Creek	46.5	1.8
Buck Creek	47.4	1.3
West Fork	48.0	3.3
Ware Creek	48.6	1.2
Hard Creek	49.0	0.9
Mine Creek	49.6	1.1

3.2 Sediment Routing Considerations

To assess which tributaries are likely to contribute coarse sediment to the study reach, tributary reaches were classified by their gradient, using the state's Watershed Analysis methodology ***(Washington Forest Practices Board, 1993; Northwest Indian Fisheries Commission, 1993)***. Doing so ***(Figure 3-1)***, indicated three major tributaries that could not contribute coarse sediment to the Deschutes River because their lower reaches include very low-gradient, wetland-dominated reaches: Spurgeon Creek (RM 10.0 right bank), Reichel Lake Creek (RM 25.5 left-bank), and Pipeline Creek (RM 31.0 left-bank) ***(Figure 3-1 and Table 3-1)***. As a consequence of the Deschutes River basin's geology and shape ***(Figure 2-1)***, and the low-gradient wetlands that characterize the lower reaches of Spurgeon, Reichel Lake, and Pipeline creeks, all of the tributaries which could contribute significant amounts of coarse sediment to the study reach are upstream of RM 35 ***(Figure 3-1)***.

Major tributaries between RM 35 and Deschutes Falls at RM 41 are steep in their headwaters (>0.06), and gentler (0.04-0.06) in their lower reaches ***(Figure 3-1)***. Nearly all of the Deschutes River upstream of the Falls (RM 41-RM 51) has a gradient of 0.02-0.04, and most tributaries above the Falls are similar to those downstream of it in having low-gradient lower reaches (0.02-0.04 or 0.04-0.06), and steep (>0.06) headwaters. However, there are four exceptions: Buck (RM 47.4), Ware (RM 48.6), Hard (RM 49.0), and Mine (RM 49.6) creeks remain steep (>0.06) to their confluence with the Deschutes River ***(Figure 3-1)***.

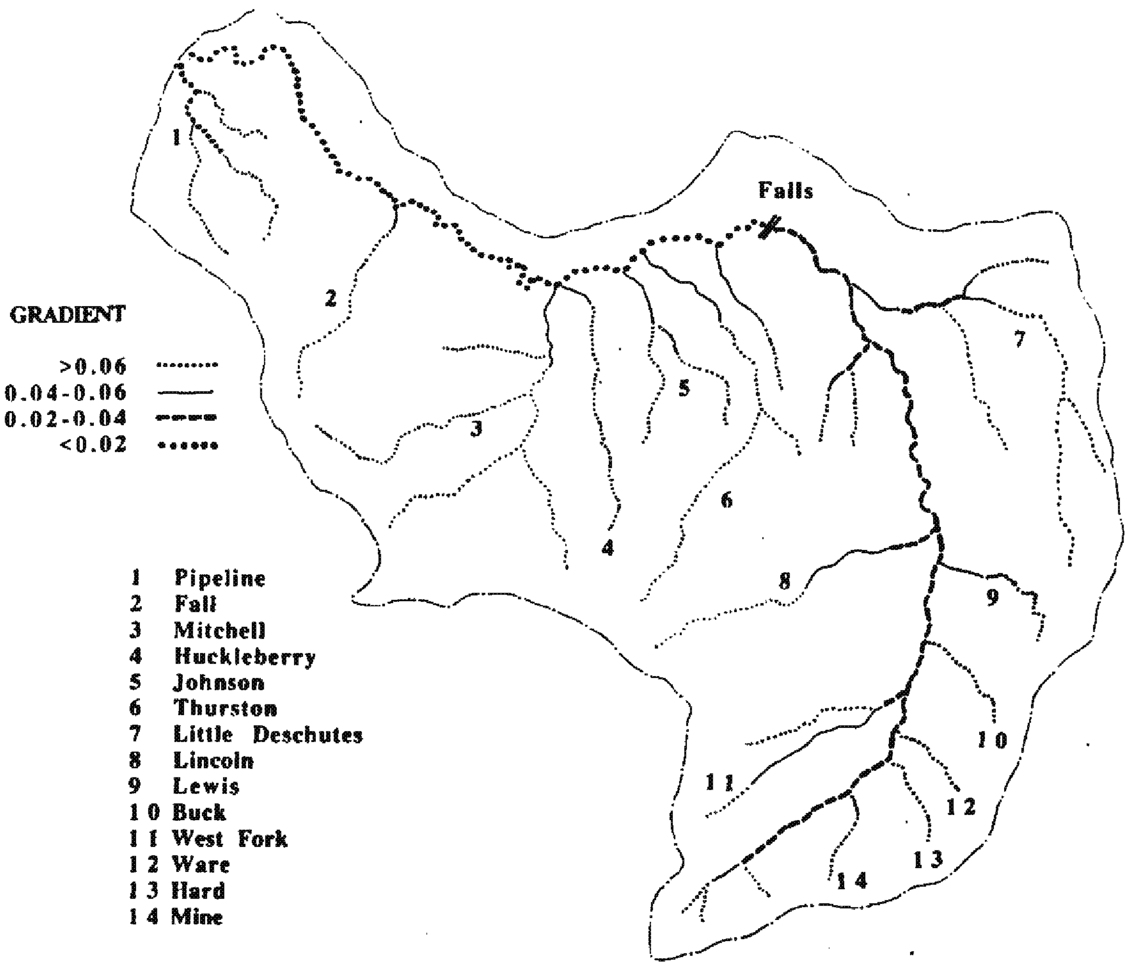

Figure 3-1. Tributary channel gradients, measured from topographic maps, for the Deschutes River basin upstream of RM 35.

Part of the rationale behind classifying stream reaches according to gradient is to predict the occurrence of debris flows. Debris flows are highly mobile slurries of soil, rock, wood, and water that can travel several miles through steep, confined channels. Debris flows often originate as shallow-rapid landslides, and can enlarge their original volume by ten times as they scour and incorporate sediment from channel margins. Besides being important agents of sediment transport, they greatly alter stream structure and aquatic habitat. Debris flows tend to travel in confined channels steeper than about 0.06, and to deposit in channels of about 0.06 and less or where tributary junction angles exceed 70° ***(Benda and Cundy 1990)***. The reach classification scheme, in combination with tributary junction angles measured from topographic maps, can be used as an initial assessment of whether or not debris flows from tributary streams would be expected to contribute directly to the Deschutes River or to deposit within tributary watersheds.

The classification scheme can also identify stream reaches which could be susceptible to dam-break floods ***(Coho and Burges 1991; Johnson 1990)***, and to predict the locations of their deposition. Dam-break floods occur when water dams behind landslide deposits or logging debris which then breaches, causing a flood which erodes channel margins and destroys riparian vegetation for up to several miles downstream. Dam-break floods, like debris flows, generally occur in confined valleys and tend to deposit where the stream loses its confinement. Unlike debris flows, dam-break floods can remain mobile at somewhat lower slopes, depositing generally at channel gradients above about 0.03 ***(Coho and Burges 1991)***.

Figure 3-1 predicts that sediment transport in the steep tributary headwaters (>0.06) is dominated by debris flows and dam-break floods. Debris flows generated by landslides which enter the four tributaries from RM 47.4 to RM 49.6 ***(Buck, Ware, Hard, and Mine creeks; see Figure 3-1 and Table 3-1)*** are expected to travel to and deposit at their confluence with the Deschutes River. Debris flows generated by landslides into Fall, Mitchell, Huckleberry, Johnson, Thurston, Lincoln, Lewis and West Fork creeks or the Little Deschutes River are expected to deposit in the lower reaches of these tributaries. Dam-break floods are similarly expected to deposit within the lower reaches of tributaries, excepting the four creeks between RM 47.4 and RM 49.6.

The relatively low gradient of the Deschutes River upstream of Deschutes Falls (RM 41-RM 51) indicates that the reach is dominated by fluvial transport and that bedload is expected to travel slowly relative to transport in the tributaries, but more rapidly, however, than in the study reach. The river upstream of Deschutes Falls is steeper (0.02-0.04) *(Figure 3-1)*, and characterized by fewer channel bars than the study reach downstream of the Falls, where the river's gradient is less than 0.02 and generally less than 0.01, and has a large number of bedload storage bars, which indicate relatively slow transport.

Finally, based on the gradient of tributaries, it is expected that some of the coarsest suspended sediment generated in tributary watersheds would deposit in the lower reaches of most tributaries, but that most suspended sediment generated in tributaries would contribute directly to the Deschutes River. These initial predictions were used to guide field and photo observations, reported on below.

3.3 Landslide and Bank Erosion Inventory

Landslide Inventory Approach. The landslide inventory included shallow-rapid landslides, debris flows, and dam-break floods. No deep-seated failures were found which actively contributed sediment to the stream network at a measureable rate. Because the intended use of the inventory is to assess the overall importance of coarse sediment influx in the watershed rather than to make a detailed assessment of slope stability and the conditions influencing it, the inventory differs in several respects from an inventory for the latter purpose:

(1) The inventory included only the part of the watershed in which coarse sediment from landslides has the potential to reach the Deschutes River, either directly or by subsequent fluvial transport from tributary deposition sites. Thus, it was confined to left-bank tributaries from Fall Creek (RM 35) to the Falls (RM 41) (combined area of 30 mi^2) and the 33 mi^2 watershed upstream of Deschutes Falls *(Table 3-1)*. The inventory area covers a total area of 63 mi^2 or 38 percent of the watershed's 166 mi^2 area.

(2) The inventory excludes landslides that did not deliver sediment to a perennial stream. Volumes were determined for

landslides that deposited directly to the Deschutes River, which would be expected to route fairly rapidly downstream. Landslides deposited in tributary streams would be expected to erode more slowly by fluvial transport, and the volume of this transport was estimated using sediment transport data, as indicated below.

(3) The inventory focuses on characterizing the cause, size, and overall effect of large events. For example, if a debris flow triggered a number of streamside landslides, those streamside landslides are not individually distinguished from the debris flow. The inventory instead focuses on the total volume of displaced material, the stream reach affected by the event, where the material deposited in the stream network, and the nature of the triggering event. For a recent example of a landslide inventory made as a detailed evaluation of the factors involved in a region's slope stability, see Dragovich and others *(1993a; 1993b)*.

The inventory made use of two previous landslide studies in the basin. Sullivan and others *(1987)* made aerial photo and field measurements of landslides occurring 1978-1986, and Toth *(1991a)* inventoried landslides from the record January 1990 storm. The Weyerhaeuser Company provided map and size information *(Weyerhaeuser Company 1993)* for these landslides and for additional landslides that occurred prior to them. All three sources covered the inventory area defined for this study (the drainage basin upstream of RM 35).

A field visit was made to the initiation and deposition sites of most landslides mapped in the previous inventories, channel conditions were examined in the major tributaries to assess sediment routing, and aerial photos from 1941 to 1991 were examined. Volume estimates rely on information from Sullivan and others *(1987)* and Weyerhaeuser Company *(1993)*. Remaining field evidence which could have been used to independently check these volume estimates is poor.

Aerial photos were examined for evidence of rapid bank erosion. Rates and locations of bank erosion under mature riparian forest cover generally cannot be determined except in the field because banks in small tributaries are hidden beneath forest canopy and rates are small *(Reid 1981)*. Without field information, photo analysis can only reveal the timing and locations of unusually rapid bank erosion. Photo-examining the Deschutes River tributaries revealed several stream reaches of significant bank erosion associated with riparian logging. The absence of tree cover in those periods and the fact that channels generally did not widen until the second photo series following riparian logging meant that it was possible to readily identify these widened stream reaches.

Chronology of Landslide Events. A total of 39 significant landslides entered streams in 1966-1972, 1978, 1982, 1986 and 1990 ***(Figure 3-2)***. Of these 39, 15 contributed to the Deschutes River ***(Tables 3-2 and 10-8)***. Landslide volumes in previous studies were reported in cubic meters; in keeping with the rest of this report, volumes are also given in cubic yards.

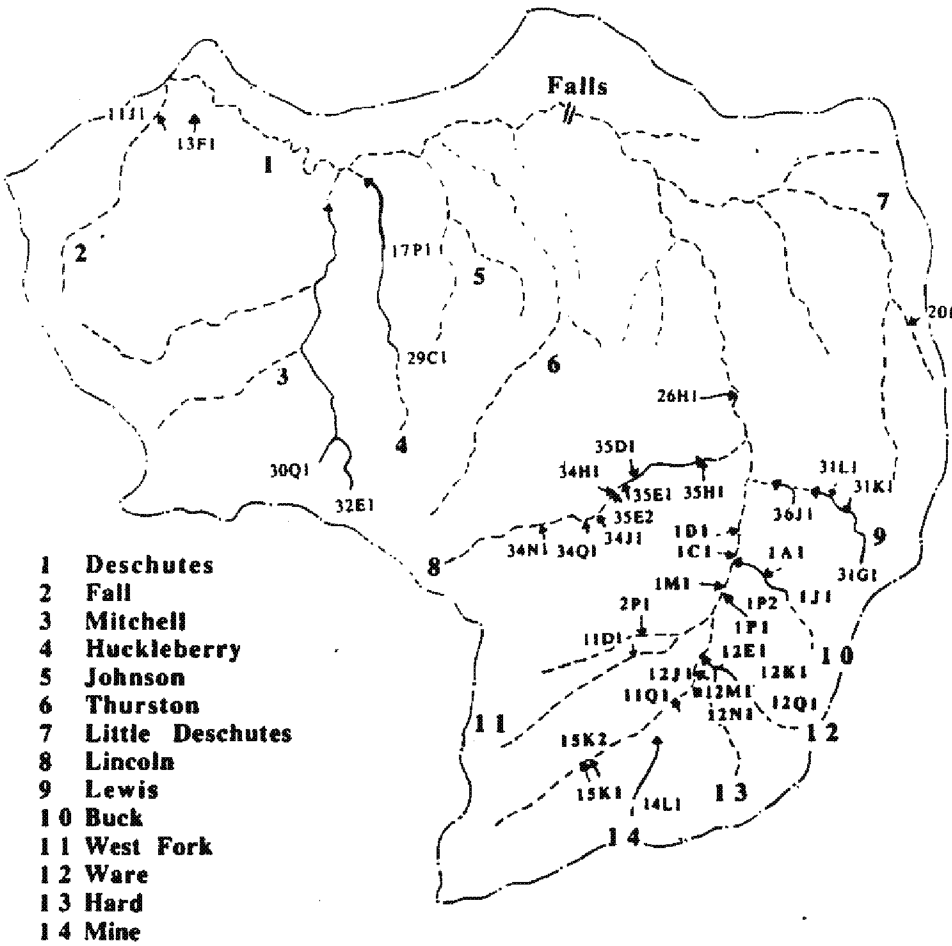

Figure 3-2. Location of landslides entering stream channels. Landslide references are to Table 10-8; landslides referenced in bold-face type delivered directly to the Deschutes River.

Table 3-2. Summary of tributary landslide and bank erosion inventory. Full landslide inventory and information sources are in Table 10-8.

Time period or year	Bank Erosion	Landslides: Number Reaching Channel	Landslides: Number Reaching Deschutes River	Landslides: Volume Reaching Deschutes River (yd^3)
<1941	1/			
1941-1954	1/			
1954-1966	1/			
1966-1972	2/	9	2	1,300.
1978		3	2	1,300.
1982		6	6	20,300.
1986		1	1	6,500.
1990		20	4	8,600.

1/ Mitchell Creek.
2/ Thurston Creek; Deschutes River (RM 43.9-RM 45.1).

Nine landslides occurred in 1966-1972. One of two events in the Mitchell Creek watershed was triggered by a road-fill failure and evolved into a major debris flow or dam-break flood which appears from aerial photos to have deposited upstream of the Weyerhacuser Company's 1000 Road, about 0.3 river miles from the Deschutes River. Debris flows occurred in Lewis Creek and Mine Creek, and stopped within 0.4 and 0.3 miles of the Deschutes River, respectively ***(Table 10-8 and Figure 3-1)***. Two stream-side failures occurred in Lincoln Creek in 1966-1972. One reached Lincoln Creek at RM 1.3 where it stopped, and the other traveled from RM 1.4 to RM 0.5. Of the nine events in 1966-1972, two entered the Deschutes River. Both were road-related failures that contributed 700 m^3 and 300 m^3 of sediment, respectively (920 yd^3 and 400 yd^3) to the Deschutes River at RM 48.8 (upstream of Ware Creek) and RM 50.6 (upstream of Mine Creek), or a total of 1,000 m^3 (1,300 yd^3) ***(Table 3-2)***.

Three landslides occurred in 1978. A road sidecast failure in a steep right-bank tributary to Lincoln Creek contributed about 4,000 m^3 (5,200 yd^3) ***(Sullivan and others 1987)*** of material to the channel of Lincoln Creek at RM 0.5, but did not continue down Lincoln Creek, which is expected because of the gradient (0.02-0.04) of lower Lincoln Creek *(Figure 3-1)*. The other two landslides were also triggered by roads, and contributed directly to the Deschutes River. A landslide at a stream crossing in Hard Creek contributed 700 m^3 (920 yd^3), and a road failure upstream of Hard Creek at RM 49.2 contributed 300 m^3 (490 yd^3) of material. The total amount of material contributed to the Deschutes River in 1978 was 1,000 m^3 (1,300 yd^3) *(Table 3-2)*.

A large storm on December 3, 1982 caused a total of six landslides in Buck and Ware creeks and along the Deschutes River in the vicinity of Buck and Ware creeks. The storm intensity approximated a 50-yr 24-hr event *(Sullivan and others 1987)*. All six landslides entered the Deschutes River, because they occurred in tributaries not having low-gradient lower reaches. Three events in the Ware Creek drainage combined to produce 10,600 m^3 (13,900 yd^3) of sediment to the Deschutes River. Two landslides on the valley slopes of the Deschutes River contributed a total of 4,900 m^3 (6,400 yd^3) to the river. Together, the six landslides produced 15,500 m^3 (20,300 yd^3) of sediment to the Deschutes River *(Table 3-2)*.

A rainstorm in 1986 having an estimated 5-yr return interval *(Sullivan and others 1987)* resulted in a landslide of about 5,000 m^3 (6,500 yd^3) to the river from the left-bank valley side of the Deschutes River between Buck Creek and the Deschutes River West Fork.

A storm in early January 1990 delivered a total of 17.4 inches of precipitation at a station in Ware Creek, an amount considerably exceeding the expected 100-yr 24-hr storm *(Toth 1991a)*. An inventory of landslides resulting from the storm found a total of 38, 23 of which entered streams *(Table 3 in Toth 1991a)*. Of these, three were in the Pipeline Creek watershed, which is outside of this study's inventory area, leaving a total of 20 landslides from 1990 *(Table 10-8)*.

Four of these twenty landslides *(Table 3-2)* entered the Deschutes River between RM 47.3 and RM 50.5, or from just below Buck Creek to a mile above Mine Creek. The volumes were estimated by the Weyerhaeuser Company at between 400 and 5,000 m^3 (520-6,500 yd^3), and totalled 6,600 m^3 (8,600 yd^3). The site of deposition within the drainage network of the remaining 16 landslides is given in Table 10-8.

In summary, sediment was contributed to the Deschutes River in five significant storm-induced landslide episodes in the basin *(Table 3-2)*. Two landslides between 1966 and 1972 contributed 1,000 m^3 (1,300 yd^3), two landslides in 1978 contributed an additional 1,000 m^3 (1,300 yd^3), six landslides in 1982 contributed 15,500 m^3 (20,300 yd^3), one slide in 1986 contributed 5,000 m^3 (6,500 yd^3), and four landslides in 1990 contributed 6,600 m^3 (8,600 yd^3) of sediment to the Deschutes River, or a total of 29,100 m^3 (38,000 yd^3) in the 25-yr period between 1966 and 1990. All of these 15 slides were located in the 3.5-mile reach of the Deschutes River between RM 47.1 and RM 50.6 and were either within Buck, Hard, or Ware creeks, or along the valley sides of the Deschutes River in this vicinity.

Summary of Landslide Causes. Twenty (just more than half) of the thirty-nine events included in this report's inventory occurred in the January 1990 storm, which was the largest on record. Another 6 occurred in 1982 in a storm thought to have had a 50-yr recurrence. Thus, two-thirds (26 of 39 or 67 percent) of the slides occurred in two large storms, in 1982 and 1990.

Roads played a role in the majority of landslides, being a factor in 23 of 39 cases (59 percent). All but one of the remaining landslides were initiated in young plantation forests ***(Table 10-8)***. The Toth ***(1991a)*** study concluded that newer roads (built in the last 15 years) were more stable in the 1990 storm than older roads (built 16-45 years before the storm). Most road landslides were caused by plugged culverts or steep cutslopes. The study's primary recommendation for reducing road damage and landslides was to replace inadequate culverts and to improve road maintenance.

The importance of roads and recent clearcuts in triggering landslides in the Deschutes River basin is consistent with studies throughout the northwestern United States. For summaries of regional studies, see Sidle and others ***(1985)***, NCASI ***(1985)***, and PENTEC ***(1991)***; for a recent study of the nearby Tilton and Mineral rivers area of Washington, see Dragovich and others *(1993a, 1993b)*.

To reiterate a point made earlier, this inventory considers only landslides that delivered to stream channels, and in some cases combines streamside landslides with debris flows or dam-break floods that triggered them. More information on landslides that did not deliver to streams can be found in Toth *(1991a)* and Weyerhaeuser Company *(1993)*.

Tributary Bank Erosion. Significant bank erosion was evident in association with riparian cutting in two tributaries and in a one-mile-long reach of the Deschutes River. It is presumed that widening occurred because riparian logging disturbed banks and reduced tree rooting strength, but this inference is based only on the available photos and no ground information. Mitchell Creek evidenced significant channel widening and an abundance of channel bars in 1941 photos, the earliest photo set found. Widening in 1941 originated in the main (west) branch where riparian logging prior to 1941 had completely removed vegetation; based on the photos and the logging practices at that time, it is likely that in-channel wood was also removed. The channel widening and abundant bars extended to the Deschutes River in 1941.

The extent of channel widening in Mitchell Creek increased in other branches as riparian logging spread through 1966, although since 1954 the canopy downstream of RM 0.3 appears closed on aerial photos, suggesting the rate of bedload transport to the mouth probably had decreased from that suggested in the 1941 photos. Channel widening is also associated with stream-side landsliding in Mitchell Creek. It is not known to what extent inner-gorge logging caused landsliding, which aggravated widening, or alternatively whether riparian-logging-caused widening triggered the stream-side landsliding. Channel widening of Thurston Creek was evident between 1966 and 1972 in several reaches of riparian logging, including to within 0.2 RM of the mouth.

The third area of significant bank erosion is the Deschutes River between about RM 43.9 and RM 45.1 *(Figure 3-1)*, just north of the boundary between Lewis and Thurston counties, and roughly mid-way between Lincoln Creek and the Little Deschutes River. This reach was logged between 1941 and 1954, during which time the channel changed from having a closed canopy to an average width of 50 feet. By 1965, channel width had increased to 76 feet and to 100 feet in 1972. The channel in the 1972 photos has numerous gravel bars, which by 1981 had begun to substantially revegetate. As a result, the channel narrowed to 24 feet by 1981. Width increased again in 1990 to about 50 feet, possibly reflecting a partial destabilization of newly revegetated bars during the January 1990 flood. A similar overall pattern of response to riparian logging and floods (widening and bar formation, later vegetative encroachment, and partial destabilization of revegetated bars in response to a flood) has been observed elsewhere in western Washington ***(Collins and others 1994)***.

Channel erosion of the Deschutes River upstream of the Falls was limited to the reach described above. Sediment production in that reach does not appear from the aerial photos to have been great, because the banks appear to be generally low, and it does not appear from the appearance of the channel downstream as though the reach produced a large amount of bedload before bars restabilized. Although the reach upstream of the Falls was not subject to a detailed field evaluation comparable to the study reach, photos and reconnaissance field observation suggest this one subreach widened in response to riparian cutting while the rest of the river upstream of the Falls did not because the subreach is broader and more alluvial, while the rest of the reach is in a narrower valley or the channel is partially formed in bedrock rather than alluvium.

3.4 Estimated Coarse Sediment Influx to the Study Reach

<u>Coarse Sediment from Landslides Delivered Directly to the Descutes River</u>. To determine how much landslide sediment is contributed to the study reach, it is necessary to estimate how long it takes for coarse sediment to travel through the Deschutes River to the study reach. It is also necessary to determine the rate at which bedload material is broken down to suspendible material during transport. These data are not available from the Deschutes River, and must be estimated from studies of other rivers.

Studies useful for estimating the rate at which gravel bedload moves include studies of gravel bedload velocity in storm events ***(e.g. Hassan and Church 1992; Hassan and others 1991)*** and of residence time of channel-stored bedload sediment ***(e.g. Madej***

1992). Without undertaking extensive field experiments to measure bedload velocity or a study of the residence times of channel-stored sediment in the upper Deschutes River, it is only possible to use results from published literature to estimate the probable order of magnitude of bedload velocity. Bedload sediment contributed to the river in the RM 47.1-RM 50.6 reach must travel five to nine miles before reaching the upper end of the study reach. Using the available studies as a guide, it is estimated that bedload would travel this distance in one to several decades.

Several studies in western Washington and Oregon ***(Collins and Dunne 1989; Perkins 1989; Benda 1993)*** and northern California ***(Madej 1992)*** included laboratory experiments to assess the rate at which bedload grains break down into suspendible-sized particles during transport; for a more general treatment of the issue, see Parker ***(1991)***. The durability of bedload particles has been found to vary to a great extent with rock type. Among rock types included in regional studies, volcanic rocks from the southern Olympic Mountains ***(Collins and Dunne 1989)*** are most similar to rocks in the Deschutes River's tributary drainages. These data ***(Collins and Dunne 1989, Table 1)*** indicate river transport of 5-10 miles would result in conversion of 20-30 percent of the original bedload material to suspended sediment, where 0.5 mm is taken as the boundary between bedload and suspended sediment. Transport of 20-40 miles would result in conversion of 50-75 percent of bedload to suspended load.

If it is estimated that 50 percent of the landslide material reaching the stream is bedload sized ***(from colluvial grain-size analyses in Snyder and Wade 1972)***, then it is possible to estimate delivery rates to the study reach, by applying the attrition and bedload velocity rates to landslide volumes. Overall, between 1966 and 1990, 19,000 yd^3 of bedload-sized material (50 percent of total landslide volume of 38,000 yd^3) was contributed to the river in the RM 47.1-RM 50.6 reach. About 14,000 yd^3 of this would make it as far as the upper end of the study reach at RM 41 after taking attrition into account, and would take one to several decades to arrive there. If the estimated bedload travel times are correct, then only about 1,000 yd^3 would have made it to the study reach by 1991, but travel time is not known with confidence. If it is assumed that all of the bedload from landsliding between 1966 and 1990 had traveled to the study reach by 1991, then this amount (14,000 yd^3) would be the upper limit to estimated tributary landslide influx to the study reach, and 1,000 yd^3 would be the lower bound, and more likely closer to the estimate. Averaged over the 1966-1991 period, this amounts to 40-600 yd^3/yr. The amount is expressed as an average annual rate for convenience only, because it facilitates comparison to other sediment sources. In reality, most bedload transport is sporadic, and occurs in large storms.

While this bedload rate was derived using several approximations and extrapolated data, for the purpose of determining the role of coarse sediment in deposition and bank erosion in the study reach *(Chapter 5)*, it is adequate to know only the order of magnitude of bedload contributed directly by landsliding in the drainage basin, and this estimate provides such an estimate.

Coarse Sediment from Fluvial Erosion of Banks and Tributary-stored Landslide Deposits. While the above provides a useable estimate of bedload contributed to the study reach from landslides delivering directly to the Deschutes River, it is possible only to broadly characterize but not to closely quantify the additional bedload supply from tributary bank erosion and tributary-deposited landslides.

As indicated previously, under mature forest, the upper Deschutes River and its tributaries probably transported a small amount of bedload derived from bank erosion of the downslope-creeping soil mantle, augmented by infrequent landslides. It is expected that rates of fluvial transport from tributaries since logging and associated bank erosion and landsliding began have been greater than in the period of low bedload supply under a mature forest. The following can be said by way of bracketing the probable increase:

(1) Riparian-logging-caused channel widening took place primarily prior to 1972 ***(Table 3-2)***, with most not primarily delivering directly to the Deschutes River, excepting Mitchell Creek before 1941 and the RM 44-RM 45 reach from 1941 to 1972. The volumes of bank-eroded sediment are not known;

(2) While volumes were not determined for tributary-stored landslides, there were about one-and-a-half times as many as there were landslides that did contribute directly to the Deschutes River,

and as an approximation it can be estimated that the amount of coarse sediment stored in tributaries was about one-and-a-half times what was contributed to the river, or 30,000 yd^3. Only some of this would have been subsequently eroded by tributary streamflow, and these landslides were after 1966, and most (two-thirds) in 1990, so that at most about a third or 10,000 yd^3 might have been eroded and transported to the Deschutes River by 1991, accounting for about 400 yd^3/yr of average delivery to the Deschutes River;

(3) Slow but ubiquitous soil-creep-driven bank erosion continued to occur in most channels not affected by logging-increased landsliding or bank erosion. This would have occurred at roughly the same (unknown) rate as under natural conditions, and is an additional source of tributary bedload.

Total Tributary Bedload Estimated from Previous Suspended Sediment Studies. While it is not possible with available sediment source information to directly quantify fluvial bedload transport, it is possible to estimate total tributary bedload by making use of previously-collected suspended sediment data. Such an estimate is independent of the estimate derived from the landslide inventory and routing assumptions, and so it serves as a useful check on that estimate. This approach makes use of proportional relations between bedload and suspended load in other basins where both have been measured. Because there is suspended sediment data from the tributaries of the Deschutes River, bedload can be estimated by using an estimated ratio ***(see Benda 1994 for summary of data from various streams).*** This approach is strictly empirical and approximate.

The ratio of bedload to total load typically varies with position in the drainage network. Immediately below colluvial sediment sources, the ratio reflects the colluvial grain size distribution, about 0.50 in the Deschutes River basin. At the mouths of headwater streams, the bedload may be 0.10 of total, and at the mouths of lowland streams such as the Deschutes, the bedload may be about 0.05 of total load.

Three previous studies included suspended sediment measurement programs in the Deschutes River. These studies were conducted by the U.S. Geological Survey ***(Nelson 1974)***, the Washington

Department of Ecology *(Moore and Anderson, 1979)*, and the Weyerhaeuser Company *(1987)*. The first study *(Nelson 1974)* did not include measurement of tributary input. The second *(Moore and Anderson 1979)* measured suspended sediment in November and December 1977 at 13 sites on the upper Deschutes River mainstem (RM 25 to RM 47) and in major tributaries to it between RM 47 and RM 25 (including the mainstem above RM 47). The investigators estimated that their sampling of tributaries included 90 to 95 percent of the total tributary contribution. The total tributary contribution (excluding the Deschutes River mainstem between RM 41 and RM 47) was 3,043 tons (2,400 yd^3). This amount accounted for only two months of the year, but can be scaled to a full year because transport was measured for the full water year at the river's mouth. Doing so indicates a tributary suspended sediment transport of 3,000 yd^3 for WY 1978.

In the Weyerhaeuser Company study, Sullivan and others *(1987)* reported on suspended sediment measurements made from 1976 to 1987 at RM 37. They excluded one year (1986) from the data because it was larger than others, but do not indicate the data are technically flawed, so that year's data is included here. The average annual suspended sediment transport measured between 1976 and 1987 at RM 37 is 15,125 t/yr (12,000 yd^3), some of which would have come from mainstem bank erosion between RM 37 and RM 41, which would cause it to overestimate tributary sediment, although it would also have excluded tributary influx from Fall Creek, which would tend to underestimate tributary sediment, but probably less than the RM 37-RM 41 inclusion would overestimate.

The WDOE and Weyerhaeuser Company data are in reasonable agreement for WY 1978, the year in which the two studies overlap. Annual yield for WY 1978 was 5,200 t in the Weyerhaeuser study, and 3,900 t in the WDOE study, with the Weyerhaeuser rate expected to somewhat overestimate tributary influx for the reason given above. Using the Weyerhaeuser Company study average and scaling it by the WDOE data to estimate tributary suspended sediment indicates that between 1976 and 1987 probable tributary suspended sediment yield is about 11,000 t/yr (8,700 yd^3/yr). Applying a probable ratio of bedload to total load of 0.10-0.20 indicates an average bedload for this period of 1,000 yd^3/yr. This amount would include all tributary sediment sources, including landslides, riparian-logging-caused bank erosion, and soil-creep-driven bank erosion.

While this is a rough estimate based on a strictly empirical approach, it appears reasonable when compared to the estimated bedload influx from landslides entering the Deschutes River since 1966 of 40-600 yd^3/yr, an additional maximum of 400 yd^3/yr from erosion of tributary-stored landslides and an amount from soil-creep-driven bank erosion which is unknown but probably no more than the rate of delivery by landslides.

3.5 Chapter Summary

Tributaries contributing coarse sediment to the study reach are upstream of RM 35. The total average annual contribution of bedload from tributaries is poorly known, but the available data indicate 1,000 yd^3/yr is a reasonable approximate estimate.

This estimate includes 39 major landslides (shallow-rapid landslides and debris flow or dam-break floods) occurring since 1966 and which reached streams. Fifteen of these reached the Deschutes River, introducing an estimated 38,000 yd^3 of sediment, roughly half of which is estimated to have been bedload sized. All of the 15 slides which directly entered the Deschutes River were located in a 3.5-mile-long reach between RM 47.1 and RM 50.6, and were caused by roads or logging. The remaining landslides were stored in tributary channels and portions of these deposits have subsequently eroded by tributary streamflow. Also included is sediment produced apparently in response to riparian logging in Mitchell Creek (<1941-1966), Thurston Creek (1966-1972) and the Deschutes River between RM 43.9 and RM 45.1 (1941-1972), as well as soil-creep-driven bank erosion that occurs under undisturbed conditions.

Suspended sediment transport from all tributary sources is estimated to have been about 11,000 t/yr between 1976 and 1987.

4.0 RATES AND PATTERNS OF CHANNEL EROSION AND MIGRATION

4.1 Definitions

The Deschutes River in the study reach has three types of banks. In the half mile immediately downstream of the falls at RM 41, the river flows through a bedrock gorge mantled by thin colluvial soils. The river has eroded some of these banks by undercutting colluvium at the slope toe, causing shallow landsliding. In some cases undercutting may have been augmented by the destabilizing effects of timber harvest on the steep inner gorge slopes.

The second type of bank eroded by the river is floodplain alluvium previously deposited by the river. Floodplain banks typically erode as river meanders migrate laterally and downstream. Most of the material eroded from floodplain banks deposits in bars and in overbank flood deposits downstream, so that floodplain bank erosion does not constitute a net sediment influx to the channel unless channel widening occurs.

The river also erodes terraces of unconsolidated glacial sediments, which vary in composition. Variously, the banks are sandy silt, sand, sand and gravel, and poorly-sorted sand-through-boulder sized mixtures *(Schasse 1987; Walsh 1987)*. Terraces range in height between 7 and about 100 feet. The river typically undercuts terrace slopes at the outside of bends, which produces significant amounts of sediment to the river. These banks are the river's primary source of sediment. These three situations are all considered "bank erosion" for the purpose of this report. However, only the first and third constitute net sediment sources, and the first produces only a quantitatively small portion of the total.

Eroded volumes are generally reported in this report as cubic yards (yd^3). Volumetric erosion is also expressed as a rate (cubic yards per year, or yd^3/yr) by dividing the volume eroded by the period of time between photo periods over which the volume was measured. It should be kept in mind that while average annual rates are useful for comparison between time periods, in reality bank erosion is not uniform in rate from year to year. Banks erode more rapidly in years of large floods, which occur sporadically. An annual average rate is thus misleading in the sense that all erosion during a ten year period, for example, may have occurred during one or two years, in response to one or two large floods.

4.2 Approach

The following approach was taken to investigate bank erosion and the factors influencing it:

(1) On aerial photos taken in 1941, 1953/54, 1965/66, 1972, 1981, and 1991, the channel banks and bars were mapped and transferred to a common scale of 1:12,000. Bank erosion sites were identified between Tumwater Falls at RM 2 and Deschutes Falls at RM 41 by comparing successive photo maps and noting areas of lateral bank movement. At each site of lateral bank erosion, the length and width of eroded bank was measured. For the 1981-1991 period, 127 eroding sites were identified.

This method is approximate, although care was taken to minimize the sources of error. A 0.3 mm pencil was used to trace channel margins onto mylar from aerial photos, resulting in a measurement precision of about ±10 feet. Shadows or vegetation obscuring banks on aerial photos is an additional source of error. At many eroding sites the bank is not obscured by vegetation, but at others, this effect could result in an additional estimated ±5 feet of imprecision. Imprecision may also have arisen from registering sequential photo maps at some sites. This could have introduced an additional estimated ±30 feet of imprecision. Because these various errors are additive, the total imprecision might range between ±10 feet to as much as ±45 feet in some cases, with the lower figure being more common. Typical recession measurements in the five different photo periods were 40-50 feet ***(Table 10-2)***. The estimated range in maximum potential imprecision of individual bank erosion measurements is thus about 25 to 100 percent.

(2) A field survey was made of erosion sites. The survey included banks identified in a previous study ***(McNicholas, 1984)*** as eroding between 1972 and 1981. The survey also included banks that appeared to be eroding at the time of the 1993 survey but were not identified at the time of the older study. During the field survey grain size was visually estimated, height of eroding banks was measured, and factors influencing erosion were noted.

The river was field-surveyed betwen RM 2 and RM 16, and between RM 31 and RM 41. While the field-surveyed reaches account for about 60 percent of the study reach, there were relatively few eroding sites in the unsurveyed reach, and the two field-surveyed reaches accounted for 80 percent of 127 eroding sites identified from the 1981-1991 photo comparison. It was originally planned to conduct the field survey after the photo analysis was completed in order to field-check the 1981-1991 photo sites, because some of the photo-identified sites might have revegetated or otherwise stabilized by 1993 since eroding between 1941 and 1991, and no longer appear active and not have been noticed in the field. However, the photo analysis was not completed prior to the field work, so that nine of the photo-identified sites were not field checked in the surveyed reaches.

Volumetric erosion was calculated from photo-measured widths and lengths, and field-measured bank heights. For the sites that were not field checked, bank heights were used from the previous study ***(McNicholas, 1984)*** and in a few cases were estimated from aerial photos and heights at nearby eroding bank sites that had been field-measured. Similarly, field data was supplemented with data from the earlier study to compute the volumetric erosion of fine material (silt and sand) and coarse material (gravel and coarser).

(3) Additional information useful for analyzing the causes of bank erosion was interpeted from aerial photos. This included the channel width between live riparian vegetation, measured at intervals of 1,000 feet between RM 2 and the falls at RM 41. In addition, vegetation and land use in the riparian corridor (within 300 feet of the river) were mapped on the 1991 aerial photo maps, and changes were noted from previous photo maps ***(Table 10-6)***. This section of the report focuses on describing rates and patterns, and Section 5 discusses the factors influencing the rates and patterns.

4.3 Rates and Patterns of Erosion and Migration

<u>Location of 1981-1991 Eroding Banks.</u> In the 1981-1991 photo interval, 127 eroding banks were distributed along the study reach, but most clustered in a few areas. To facilitate comparison of conditions with position along the river, sites were grouped in two-mile-long reaches ***(Figure 4-1)***. Figure 4-2A shows the distribu-

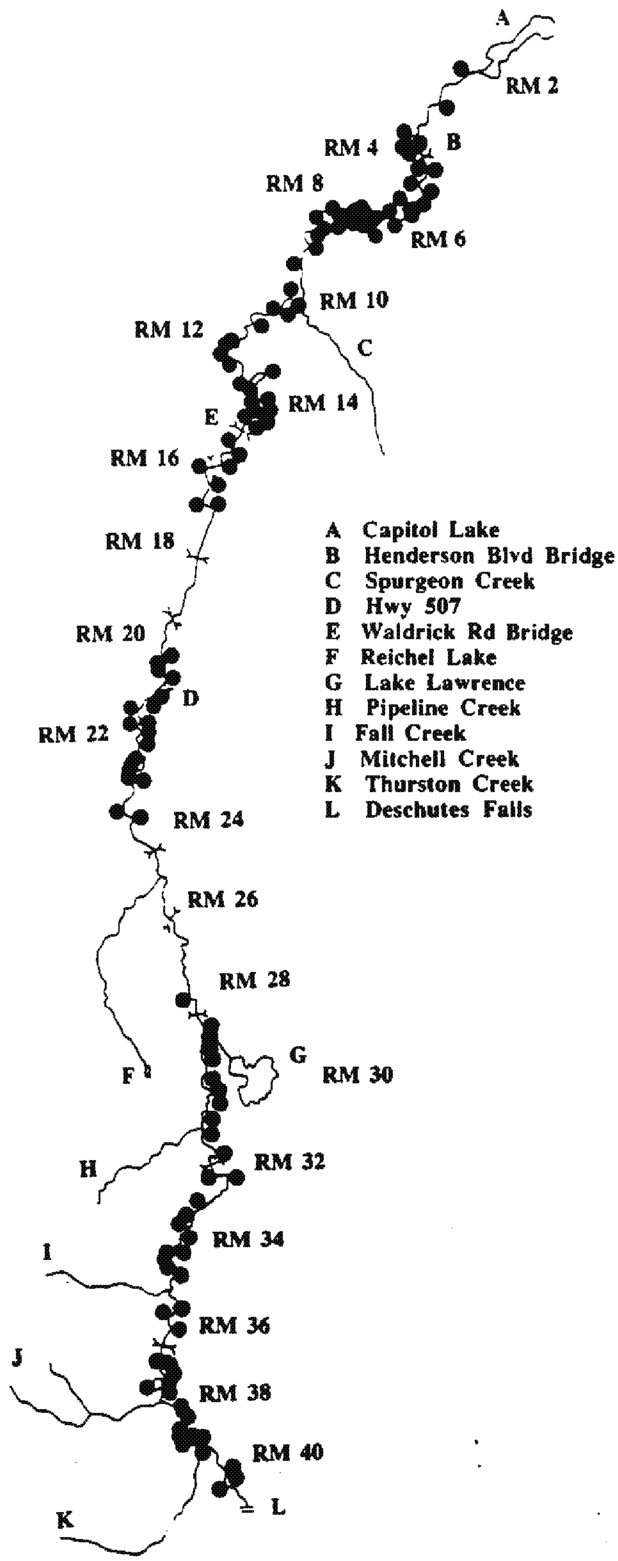

Figure 4-1. Schematic map of 1981-1991 erosion sites. Detailed locations are shown in Figure 10-1.

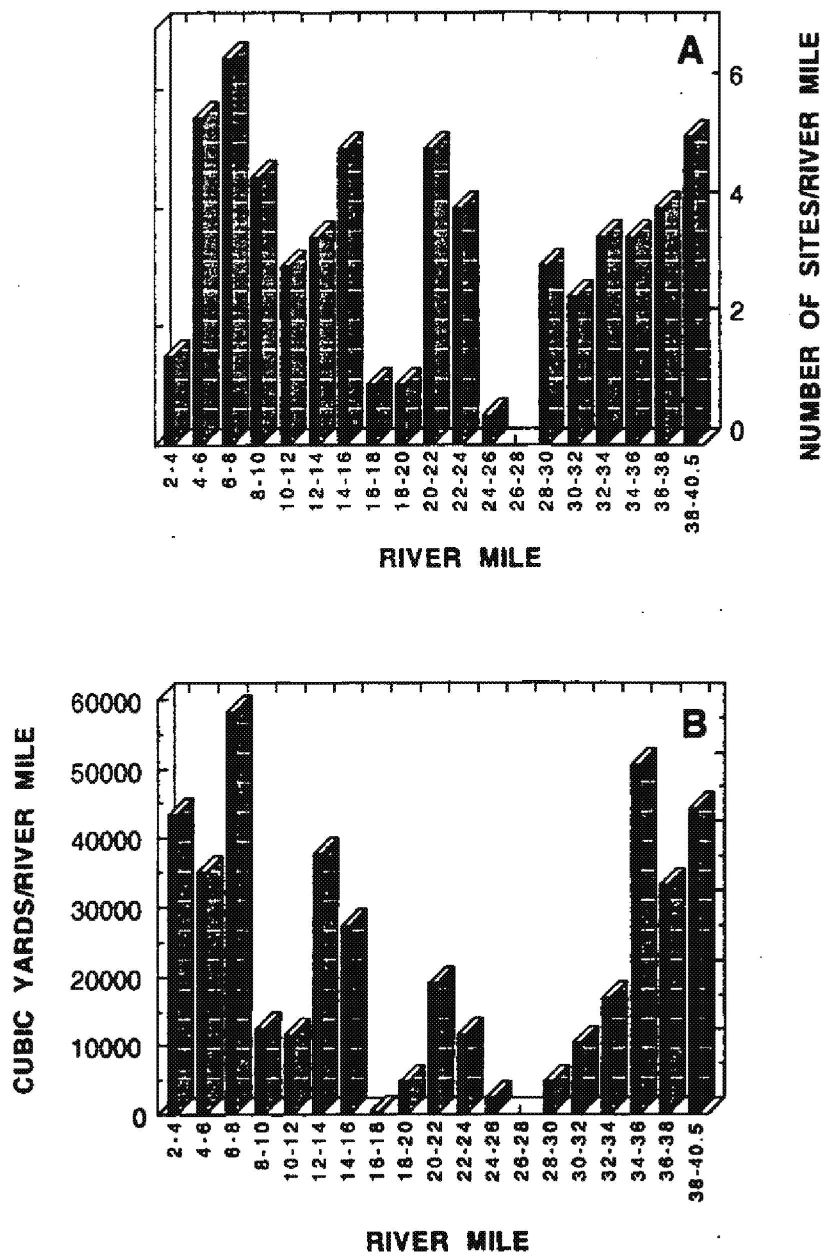

Figure 4-2. Eroding banks, 1981-1991, RM 2-RM 41, per 2-mile-long segment: (A) Number of sites; (B) Volumetric erosion.

tion along the river of the 127 eroding sites. Eroding sites cluster in three general areas: RM 4-16, RM 20-24, and RM 28-40.5. However, most of the sites in the second of these three reaches (RM 20-24) were small in volume so that most bank erosion is roughly in RM 2-8, RM 12-16, and RM 34-40.5 ***(Figure 4-2B)***.

Volume of 1981-1991 Bank Erosion Sites. In total, the 127 sites mobilized 870,000 yd^3 of sediment between 1981 and 1991, or 87,000 yd^3/yr when averaged over the ten-year period. Only a portion of this amount is transported to the Deschutes River's mouth; sediment routing will be discussed in Section 4.4.

Of the 127 sites, 22 produced more than 10,000 yd^3 (1,000 yd^3/yr). Together, these 22 largest sites (17 percent of all sites) accounted for more than half (53 percent) of volumetric total erosion. At the other end of the scale, the 50 smallest sites (smaller than 3,162 yd^3 or 310 yd^3/yr) account for only 9 percent of the total. The middle-sized sites (smaller than 10,000 yd^3 and larger than 3,162 yd^3) accounted for 38 percent of the total. Of the 22 largest sites (greater than 10,000 yd^3 in volume), half were between RM 34 and RM 41. The other 11 of the 22 largest sites are located between RM 4 and RM 16 ***(Figure 4-3)***.

The volume of bank erosion sites is important because it focuses attention on sources that might be particularly important both from an erosion control and a spawning-gravel source standpoint. This information will be discussed in Section 7 of this report, along with information on factors influencing erosion from Section 5.

Height of Eroding Banks. Most (81 percent) eroding banks were 10 feet high or less, and accounted for 60 percent of total volume. The 19 percent (24 of 127) of banks higher than 10 feet accounted for 40 percent of total eroded volume. Banks greater than 10 feet in height were located between RM 2 and RM 16 and between RM 32 and RM 41 ***(Figure 4-4)***. Twelve of these sites higher than 10 feet were also among the 22 largest (greater than 10,000 yd^3) sites ***(Table 4-1)***.

The height of banks is important because it influences the type of control measure that may be effective at slowing erosion, and factors that may be influencing erosion. Organizing sites by height

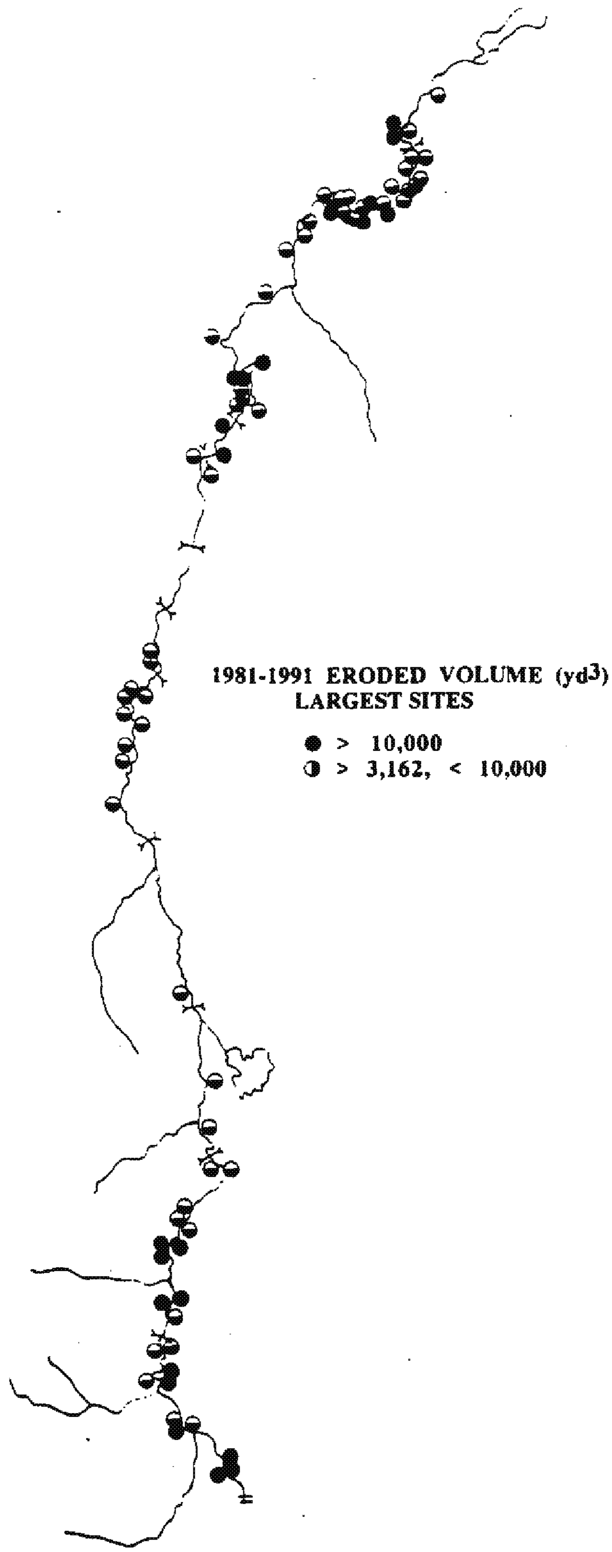

Figure 4-3. Locations of largest eroding sites.

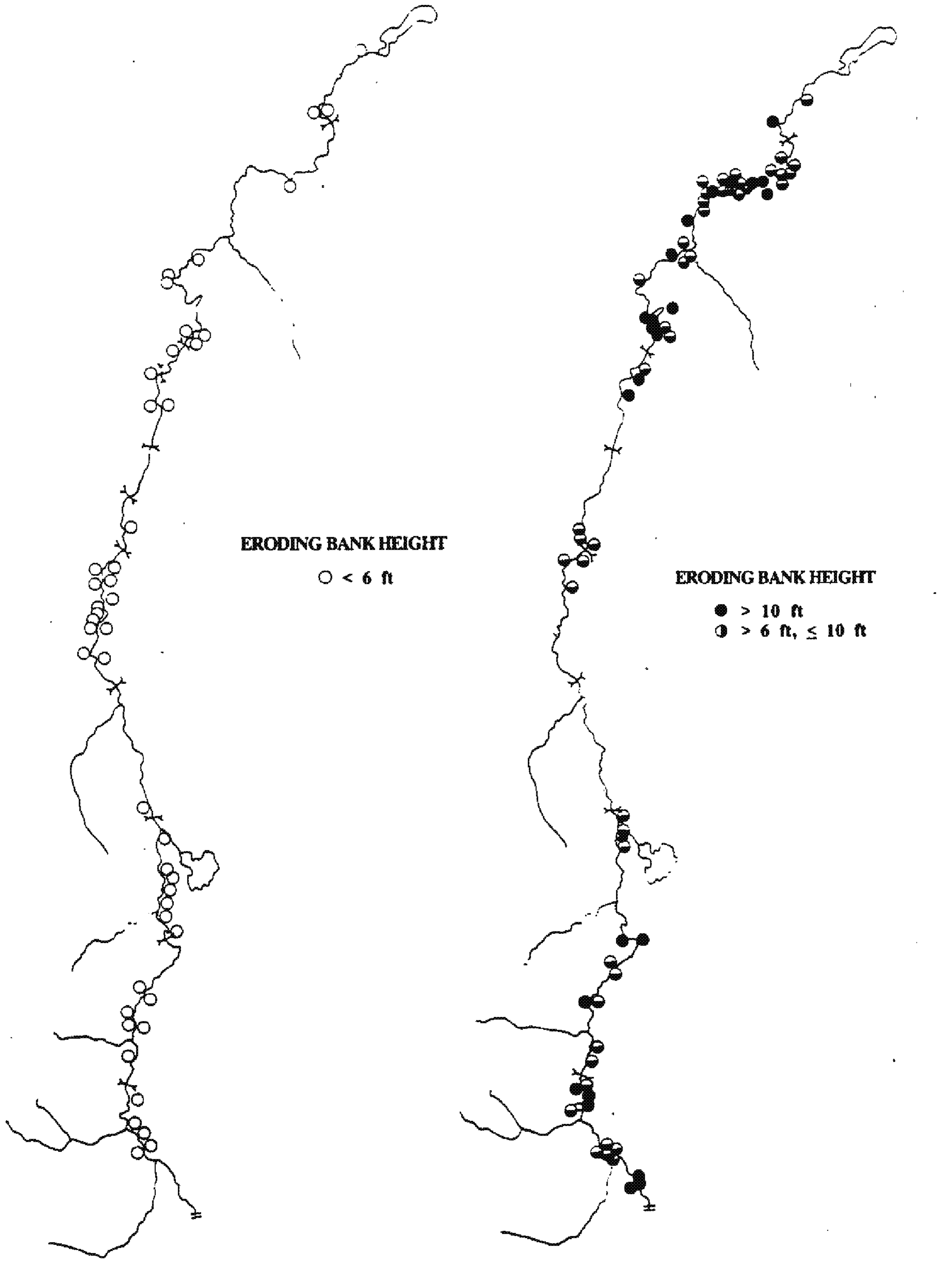

Figure 4-4. Locations of eroding banks having heights of 6 ft and less, 10 ft and less, and greater than 10 ft.

and size (which indicates the overall importance of the site) ***(Table 4-1)*** is useful for prioritizing sites in developing a strategy for riparian management, to be discussed in Section 7 of this report, *along with information on factors influencing erosion from Section* 5.

Table 4-1. Erosion sites, 1981-1991, organized by volume and height.

	ERODED VOLUME		
BANK HEIGHT	Big (>10,000 yd^3)	Medium (<10,000 yd^3, >3,162 yd^3)	Small (<3,162 yd^3)
Tall (>10 ft)	110, 180, 200, 565, 590, 595 *690, 1095*, 1250, 1430, 1440, 1450	190, 240, 410, 602, 710, 1030, *1040, 1210*, 1240	360, 610
Medium (>6, ≤10)	285, 330, 1090, 1150/1160, 1310	105, 160, 170,130, 171, 171.5, 172, 173, 210, 230, 235, 260, 270, 280, 370, 380, 460, 625, 760, 770, 800, 828, 1080, 1190, 1220, 1270, 1320	350, 361, 430, 435, 440, 500, 605, 620, 680, 772, 780, 830, 910, 950, 960, 980, 1025, 1068, 1070, 1330, 1340
Short (≤6 ft)	120, 220, 670, 1120, 1170, 1275	117, 135, 140, 535, 630, 640, 700, 790, 815, 820, 840, 860, 895, 897, 1001, 1020, 1082, 1083, 1100, 1300, 1442	100, 480, 520, 540, 650, 730, 740, 750, 818, 838, 880, 888, 890, 896, 930, 990, 1011, 1015, 1130, 1230, 1279, 1280, 1290, 1350

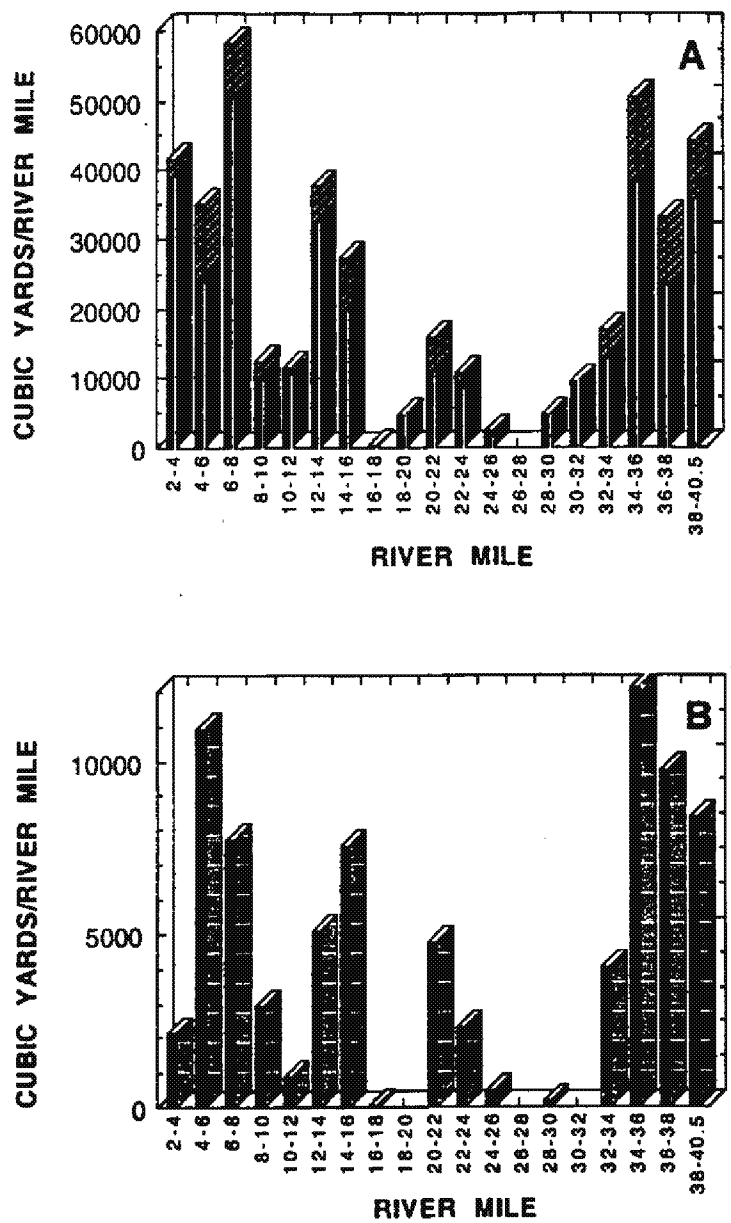

Figure 4-5. For 1981-1991: (A) Amount of fine sediment (solid bar) and coarse sediment (patterned bar) per 2-mile-long stream segments, and (B) amount of coarse sediment per 2-mile-long segment.

Table 4-2. Erosion sites, 1981-1991, organized by volume and grain size (percent <2 mm, or sand-sized and smaller).

	PERCENT < 2 MM				
<u>ERODED VOLUME</u>	100%	≥80% <100%	≥60% <80%	≥40% <60%	<40%
Big (>10,000 yd^3)	220, 285, 590, 670, 1170	110, 330, 1090,1310, 1095,1440, 1450,	120, 180, 200, 565, 595, 1150-1160, 1250, 1275, 1430	1120	690
Medium (>3,162 yd^3, <10,000 yd^3)	172, 173, 230, 235, 270, 535, 640, 700, 760, 815, 1001, 1020, 1040	105, 135, 160, 190, 210, 260, 370, 460, 625, 630, 770, 846, 860, 895, 897, 1080, 1082, 1083, 1100, 1210, *1240*, *1320*, 1442	117, 140, 240, 280, 380, 800, 1220, 1270	170, 171, 171.5, 410, 602, 820, 1300 1190	710, 790, 1030
Small (<3,162 yd^3)	361, 500, 540, 605, 650, 730, 750, 880, 910, 950, 960, 980, 990, 1011, *1015*,*1230*	100, 350, 360, 430, 435, 440, 520, 680, 772, 740, 780, 838, 896, 930, *1068*,*1070*	480, 830, 888, 890, 1279, 1330	1290, 1340, 1350 1130, 1280	130, 610, 620,

<u>Grain Size of 1981-1991 Eroded Sediment.</u> The majority of eroded material is sand-sized and smaller. According to bank material size estimates made for this study and the McNicholas *(1984)* study, 80 percent of material eroded is sand and finer, and 20 percent is gravel and coarser. The ratio of fine versus coarse sediment is generally constant with distance along the river ***(Figures 4-5A)***.

The areas of significant coarse sediment influx cluster aroung RM 4-10, RM 12-16, RM 20-24, and RM 32-40.5. The largest contributor of coarse sediment is RM 32-40.5, and the second largest is RM 4-10. Figure 4-6 shows the location of eroding banks of more than average amounts of fine sediment (>80 percent) and Table 4-2 organizes them by size.

The location of coarse sediment influx along the river is important because these stream-side sources are the primary source of spawning gravels. The location of coarse sediment influxes is also important because it is the primary determinant of reaches that have the potential to undergo noticeable aggradation or build up of material on the streambed. These issues will be discussed more in sections 6 and 7 of this report.

Comparison of Field-identified and Photo-identified Eroding Banks. In the field survey, the "activity level" of erosion was visually observed at sites identified as active by McNicholas *(1984)* and at additional sites that appeared active during the 1993 field visit, but were not identified in the 1984 study. Sites were ranked "stable" if revegetated and not visibly eroding, or if isolated from the channel by a meander cutoff or other channel change. Sites were "unstable" if most of the site was visibly eroding. "Partially active" sites had characteristics in between the others.

Overall, field indicators of activity correlated poorly with 81-91 photo-identified erosion. Of the 134 sites visited in the field, 106 were either "active" (40) or "partially active" (66). Of these 106, 70 were identified on the aerial photo measurements, meaning that 36 sites, or about one-third of the sites identified as active or partially active in the field did not indicate measureable change on the photos ***(see Figure 10-1 for list of individual sites)***. This may indicate incipient activity at some of these 36 sites. It may also indicate that some of these sites erode chronically but slowly. Only 8 of the 36 sites noted in the field but not on photos were rated "active." On the other hand, in the field-visited reaches, 24 sites were photo-identified, but were not noted in the field. That these sites were identified on photos but not in the field is presumed to be because sites that eroded during the 1981-1991 period had already stabilized since the last significant bank-eroding event in the 10-year period, presumably the January 1990 storm in many cases.

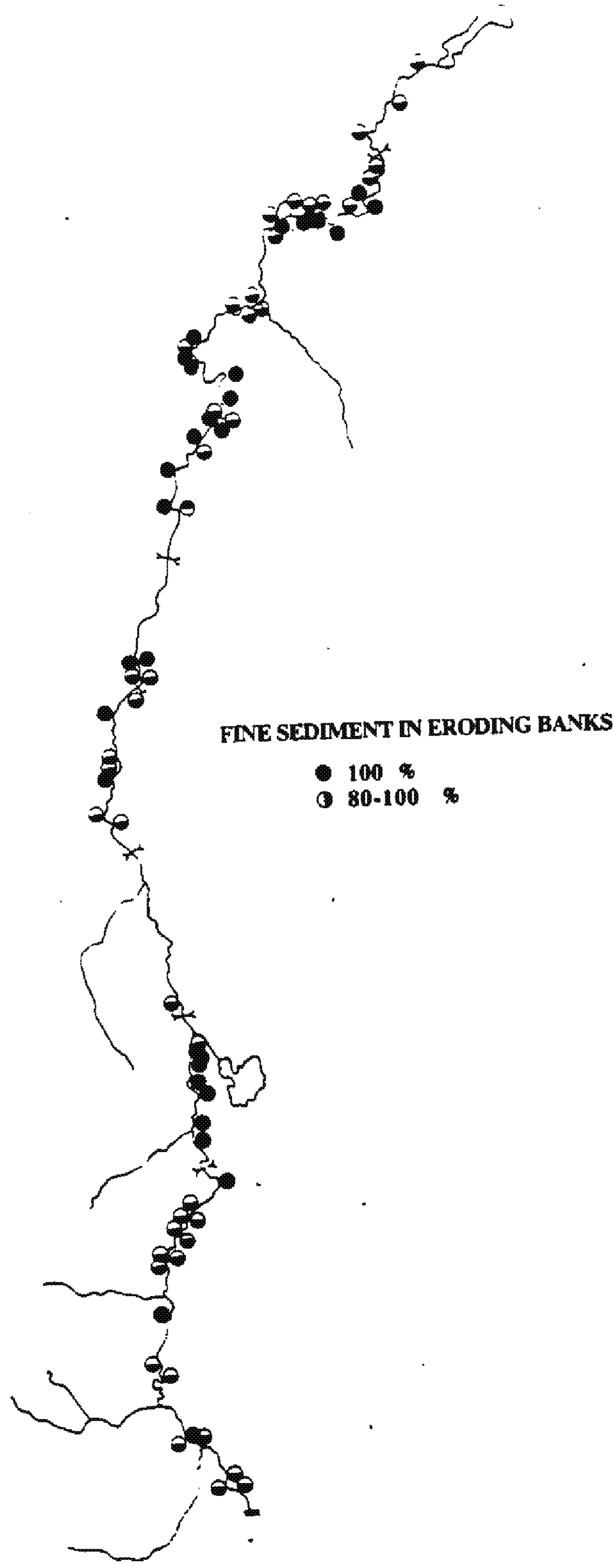

Figure 4-6. Location of eroding banks more than 80 percent finer than 2 mm.

This comparison of photo and field inventories suggests the photo approach may be a more reliable means of identifying significant erosion sites than field observations, and that it would also be desirable to have independent field measurements to confirm photo-measured bank erosion. The best approach to identifying and measuring erosion rates would be to make photo measurements, then to field-check banks identified in the photos, supplementing photo measurements wherever possible by recorded ground measurements of the length and width of eroded area.

<u>1972-1981 Bank Erosion.</u> The McNicholas *(1984)* study noted 144 sites in RM 2-41 in 1972-1981, while our photo measurements for the same period indicated 94 sites. To compute a volume from our 1972-1981 photo data, we used the bank heights measured in the 1984 study, augmented by our 1993 measurements on banks not identified in the earlier study. From these data we determined a volume of 330,000 yd^3 or 37,000 yd^3/year. However, our bank heights, measured in the field with a stadia rod, average five feet more than the same banks measured in the earlier study (17 feet compared to 12 feet at 76 sites where measurements were made in both studies). The reason for this difference is unknown. Using our field heights, we estimate 53,000 yd^3/yr of erosion in 1972-1981.

The reasons for the different number of sites identified in our study compared to the older study is also unclear. Sixty-nine of our sites corresponded with the 1984 study's, and 25 of our sites were not identified in the earlier study. Some sites in the earlier study were not active in any photo period from 1941 to 1991. The report indicates that bank heights and recession rates were field measured, then confirmed on the 1972 and 1981 aerial photographs, but does not indicate what field observations were used as evidence of lateral recession rate. If however, the sites were primarily field identified, then our experience indicates that it is not possible to accurately identify in the field the same sites noted on photos, and this may be the reason for the discrepancy. Our recession distances (widths) are also more than twice those measured in the previous study, averaging 45 feet versus 20 feet in the older study. In many cases, the 1984 study recession rates were as small as 0.1 ft/yr. The reason for this difference or how recession rates were measured in the older study is not clear.

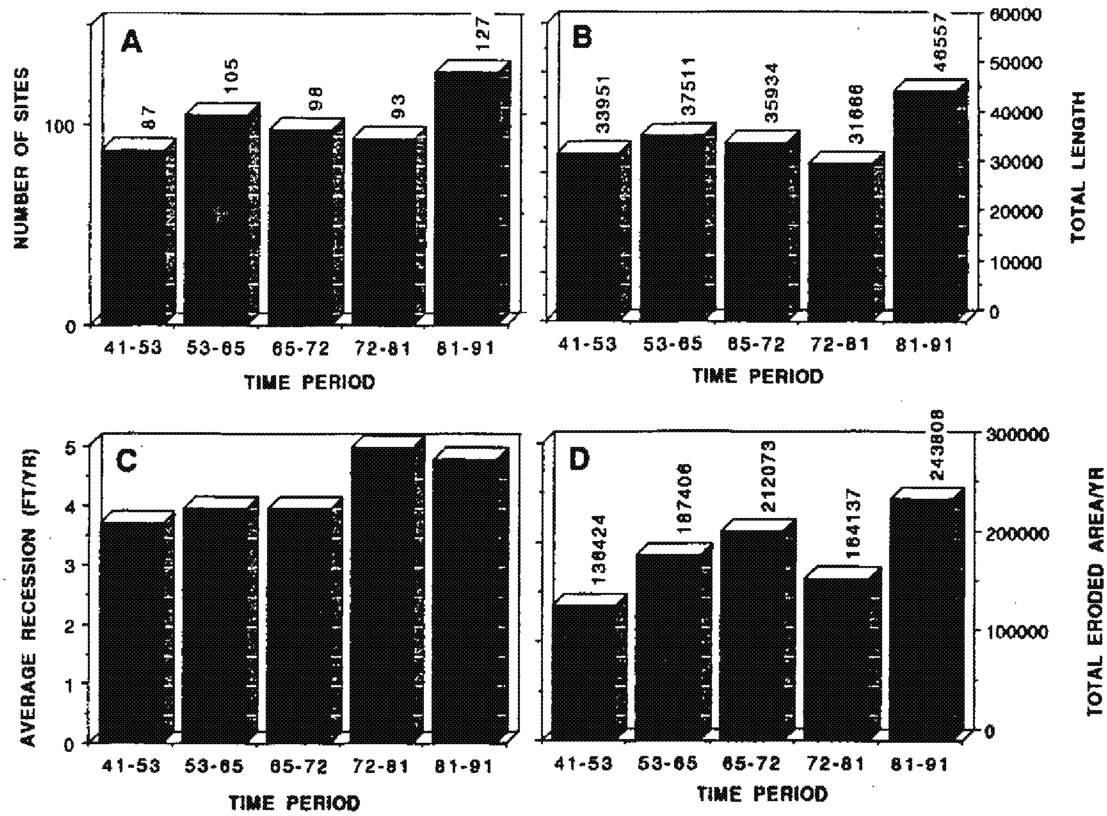

Figure 4-7. For each of five time periods bracketed by aerial photographs: (A) Number of erosion sites; (B) Total length of eroding bank; (C) Average annual recession rate; (D) Aerial extent of eroded bank.

<u>Variation in the Rate of Erosion, 1941-1991.</u> To determine whether there was significant change in erosion rate in the 50-year period of analysis, Figure 4-7 compares recent bank erosion with erosion in previous decades, as measured on the aerial photographs. Because we did not have bank height estimates from earlier periods, areal erosion is computed but not volumetric erosion. Figure 4-7A shows that the number of eroding banks ranged from 93 to 105 between 1953 and 1981. There were slightly fewer (87) in the 1941-1953 period, and more in the 1981-1991 period (127). Some of this

difference may be from measurement imprecision, because the 1941 and 1953/54 photos were smaller scale and poorer quality than the older photos, and it may have been more difficult to identify eroding sites in this earlier period than in later periods.

The total length of eroding bank *(Figure 4-7B)* varied between 31,666 ft in 1972-1981 to 46,557 ft in 1981-1991, and the average rate of bank recession *(Figure 4-7C)* varied between about 3.5 ft/yr in 1965-1972 to 5.0 ft/yr in 1972-1981. The total area of eroded bank *(Figure 4-7D)* was least in the 1941-1953 period and most in the 1981-1991 period. The 1981-1991 area is 137 percent of the 50-year average, or 152 percent of the previous 40 years. The 1941-1953 area is 77 percent of the 50-year average, or 72 percent of the 1953-1991 average.

It is unclear whether there is a significant difference between the periods, because of the fairly large and poorly defined measurement errors described previously, as well as potential inconsistencies in discerning eroding sites on photos of varying quality and scale. Factors that could potentially have caused differences in erosion rate through time are discussed in Section 5.

Table 4-3. Persistence of erosion sites. "Very Persistent": active all five time periods; "Moderately Persistent": active 1981-1991, 1972-1981, and one or more earlier periods; "Recently Persistent": active 1981-1991 and 1972-1981; "Periodic": active 1981-1991, and or more other periods, but not in 1972-1981; "New": active 1981-1991 only; "Dormant": previously active, but not in 1981-1991.

Persistent					
Very[1/]	Moderately[1/]	Recently	Periodic	New	Dormant
9	41	13	47	18	90

[1/]Includes twelve of the largest sites: 110, 120, 590, 670, 690, 1090, 1120, 1150/60, 1170, 1310, 1440.

Persistence of Erosion Sites. The persistence of erosion sites was assessed because it could be useful in assessing the efficacy of different approaches to managing bank erosion *(Section 7)*. Table 4-3 groups sites according to descriptors of their persistence. The most immediate conclusion from the table is that a large number of sites (90) were active in the past, but not in the 1981-1991 period, suggesting that many erosion sites are ephemeral. In addition, a large number (47) were active in 1981-1991 and also in at least one period prior to 1972, but not measurably so in 1972-1981, and thus could be considered periodically active.

About half of the 1981-1991 sites were persistent to some degree. Sixty-five of these were either very persistent (9 that were present in all periods), persistent (41 that were active in 1981-1991, 1972-1981 and one other period), or recently persistent (47 that were active 1981-1991 and 1972-1981). Eighteen were new in 1981-1991. Twelve of the persistent or very persistent sites were among the 22 largest sites *(Table 4-3)*. Taken as a whole, Table 4-3 indicates that about half of the 1981-1991 erosion sites are periodically active or new, and half are persistent to some extent.

Variation in Location of Bank Erosion, 1941-1991. Variation through time in the number of eroding banks with position along the river is summarized in Figure 4-8. Each of three reaches (RM 2-22, RM 22-34, and RM 34-40) reflects the overall pattern in number of sites through time *(Figure 4-8)*. The reach between RM 34 and RM 40 has a different pattern than the other two reaches, with site number continuing to increase in the 1965-1972 period, while in the other two reaches the number of sites decreases. Possible reasons for this are explored in Section 5.

Rates and Patterns of Channel Migration. To evaluate the rates and locations of channel migration, the channel position in three representative years (1941, 1965/66, and 1991) was plotted on a common map to indicate the reaches that have been the most laterally mobile. No reaches in the 50-yr period had a migration zone greater than about 500 ft, or roughly 5 channel widths *(Table 4-4)*, and 13 river miles experienced no movement in the 50-yr period. Another 13 river miles had a migration zone of 100-500 ft, and the remaining 13 RM indicated slight lateral migration of 0-100 ft. The reaches that showed a migration zone of 100-500 ft are all within RM 4.5-RM 15.1 or RM 33.5-RM 40.5, the same reaches in which eroding banks cluster.

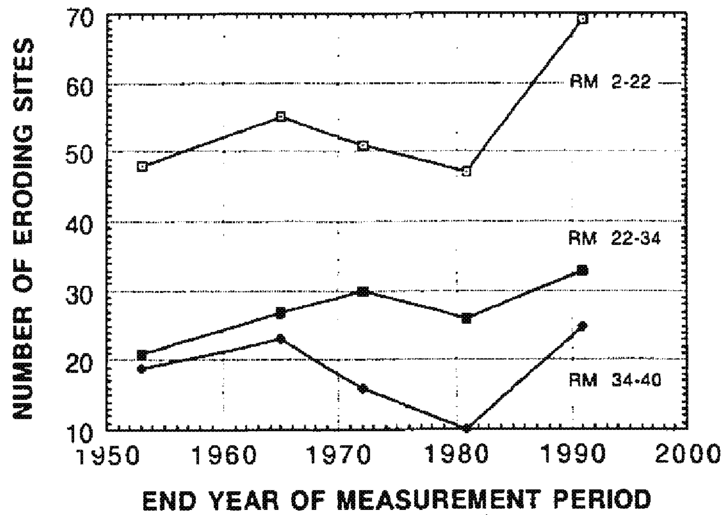

Figure 4-8. Variation in number of eroding banks, 1941-1991, in three stream reaches.

Table 4-4. Variation in width of meander belt, 1941-1991 along the Deschutes River. 0= stable; 1=slight migration, meander belt 0-200 ft; 2=moderate migration, meander belt 200-500 ft.

Reach (RM)	Index of Meander Belt Width	Reach (RM)	Index of Meander Belt Width
2-4	0,1	23.3-28.5	0
4.0-4.5	2	28.5-29	1
4.5-4.6	0	29-29.9	0
4.6-8.9	1,2	29.9-30.7	1
8.9-10.8	0,1	30.7-31.3	0
10.8-13.1	1,2	31.3-31.9	1
13.1-14.5	0	31.9-32.6	0
14.5-15.1	1,2	32.6-33.5	1
15.1-16.1	0,1	33.5-36.6	1,2
16.1-20.2	0	36.6-37.7	0
20.2-21.9	1	37.7-38	0
21.9-22.7	0	38-40.5	1,2
22.7-23.3	1		

Variation in Channel Width. The unvegetated channel width was measured in the channel reaches in which active bank erosion was noted *(Table 4-5)*. This included 31.7 RM of the study reach. Channel width varies through time in each of three reaches (RM 2-RM 17.4; RM 19.5-RM 23.6; and RM 28.5-RM 40.7), with widths being greater in 1941 and 1972 than in other years *(Figure 4-9)*. In other streams, channel width has been observed to vary with time in response to the effects of floods on channel-bar vegetation and on bank erosion. Widths increase as floods destabilize bar vegetation and erode banks, and decrease as bars revegetate and banks stabilize.

Table 4-5. Average channel width between live riparian vegetation. Widths were measured from aerial photographs in reaches where bank erosion was occurring. Width was measured at intervals of 1,000 ft on scale-corrected channel tracings.

	Average (ft)	Number	Standard Deviation	Standard Error
RM 2 -RM 17.4:				
1941	109.5	84	52.4	5.7
1953	85.7	87	51.5	5.5
1964	78.7	84	47.3	5.2
1972	104.6	89	70.4	7.5
1981	81.8	85	61.0	6.6
1991	75.6	90	54.2	5.7
RM 19.5 -RM 23.6:				
1941	108.8	24	31.6	6.5
1953	90.6	20	46.8	10.5
1964	78.8	23	51.8	10.8
1972	93.6	22	65.2	13.9
1981	78.8	23	43.2	9.0
1991	78.3	21	36.9	8.1
RM 28.5 -RM 40.7:				
1941	106.9	70	41.8	5.0
1953	101.8	71	57.5	6.8
1964	97.2	71	57.2	6.8
1972	119.8	69	67.8	8.2
1981	101.3	70	48.5	5.8
1991	112.6	69	83.6	10.1

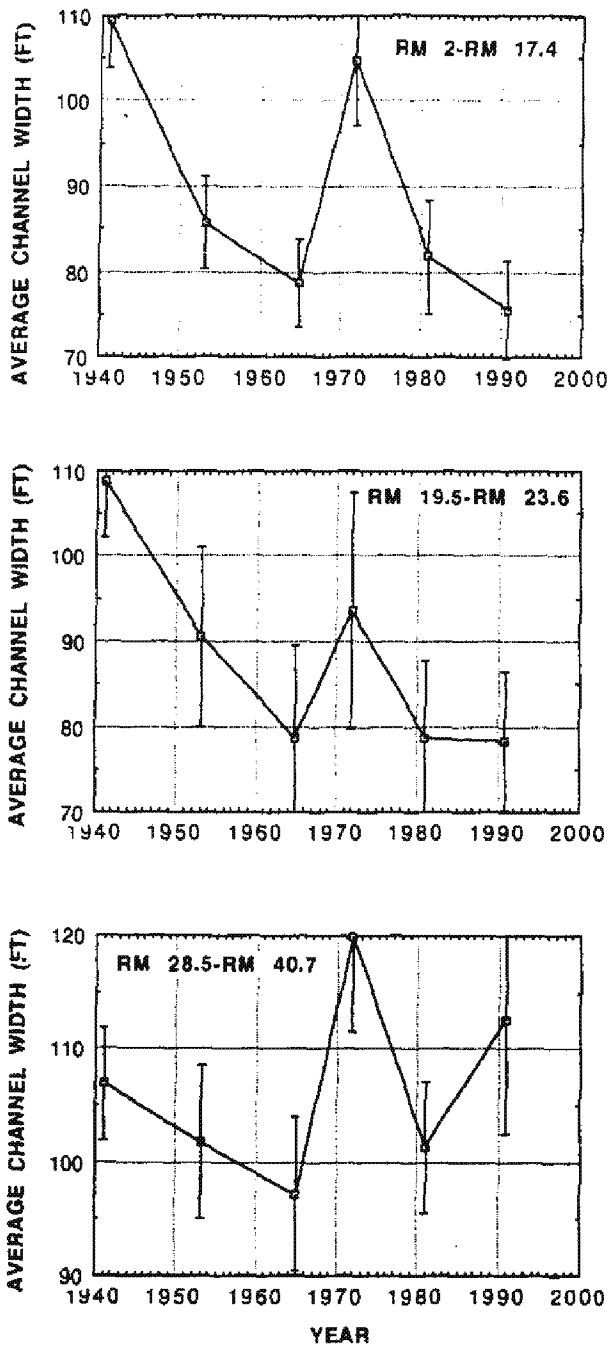

Figure 4-9. Mean and standard error of measured channel width in three reaches having active banks. Data is from Table 4-4.

With this possible correspondence in mind, the trend in channel width was compared to the general size of floods in intervening time periods. The large standard errors of estimate in Figure 4-9 mean that differences between periods are weakly or not significant. The channel appears to be wider in all reaches in 1972, although it is not statistically so except in the downstream reach. The 1972 width could possibly be explained by the pattern of flooding, as suggested above. Width decreased from 1941 to 1965/66, when there were no floods having greater than a 10-yr recurrence *(Figure 2-2)*. The channel widened from 1965/66 to 1972 which included the third largest flood or record ***(Figure 2-2)***, several months prior to the 1972 photos. The width decreased slightly from 1972 to 1981. While this period also included a comparable sized-flood in 1974, if this interpretation is correct, bars would have partially recolonized by time of the 1981 photos, obscuring the 1974 flood effects. It is unclear why in the two downstream reaches there is no increase in width in 1991 following the January 1990 flood, which would be predicted by this interpretation.

While it is possible that flood history explains the apparent trend in width, the only conclusions that can be made with confidence are that the changes in width are relatively small, in most cases less than the measurement precision ***(Table 4-5)***, and overall the channel width has not increased systematically through time, despite the bank erosion rates measured.

4.4 Routing of Bank-Eroded Sediment

To make an approximate estimate of the fate of eroded bank sediment, an assumption was made, based on the observation that bank erosion is not causing the channel to widen systematically through time. There is not a geomorphic reason why the river would be expected to widen with time, unless there had been a significant, systematic change in the coarse sediment or flood regime, neither of which appears to have occurred. In a geologic context, while the river is gradually widening its valley by undercutting terraces at the margin of the migration belt, the river replaces the eroded terrace with a floodplain as some of the eroded material is redeposited in bar and overbank deposits, thus conserving bank width. From a geometric standpoint, the net influx of material to the river is represented by the difference between the height of the active floodplain and that of eroded terraces. Six feet was taken as the average height above the channel bed of the contemporary floodplain

Working from this assumption, the volume of bank erosion that is a net sediment influx was calculated by subtracting six feet from all bank heights. This calculation indicates that for 1981-1991, the total sediment influx is 35,000 yd^3/yr. Using a typical density for bank sediments, this represents 44,000 t/yr. For 1941-1981, the average sediment influx would be 26,000 yd^3/yr, or 33,000 t/yr.

Of these amounts, about 80 percent is sand-sized or smaller, most of which would be suspendible during floods. Thus, during the 1981-1991 period, about 28,000 yd^3/yr (35,000 t/yr) would be the suspended load contribution from terrace erosion. During the 1941-1981 period about 21,000 yd^3/yr (26,000 t/yr) would be the suspended load contribution. The remaining 20 percent is gravel-sized and larger, and would be confined to the bedload. During the 1981-1991 period, the contribution to the bedload would be 7,000 yd^3/yr (9,000 t/yr), and in 1941-1981, 5,000 yd^3/yr (7,000 t/yr).

A second assumption used in routing bedload sediment is based on the attrition data discussed in Section 3. That data indicates that within about 20 miles of transport, about half of a bedload-sized sediment influx will have been converted to suspended load; within 40 miles, about 75 percent would have been broken into suspendible materials. Thus, most bedload contributed by the upstream concentration of eroding banks (approximately RM 34-RM 40) would either have deposited within an aggrading reach (Section 6), or would have been broken down into suspendible particles before reaching the downstream clustering of sites. In addition, some but not all of the bedload influx from the downstream clustering of sites (RM 2-RM 16) will have deposited or been converted to suspended load before it reaches the mouth.

4.5 Bank Erosion Rates from Suspended Sediment Studies

Previous suspended sediment transport studies provide an independent measure of the bank erosion rate, and also an indication of how much of the river's suspended load originates from mainstem bank erosion. Tables 4-6 and 4-7 summarizes available studies. The information is fragmentary, but can support several conclusions:

Table 4-5. Summary of suspended sediment fluxes from published studies.

Water Year	Annual Flux (t)				
	RM 2	RM 25	RM 37	RM 47	Tributaries
1961-63[1]	32,000				
1965-66[2]	30,000				
1971-73[3]	25,000				
1978[4]	23,000	16,000		300	3,900
1976-87[5]			15,000		
1978[5]			5,200		

[1]Orsborn and others *(1975)*, referenced in Sullivan and others *(1987)*.
[2]Puget Sound Task Force of the Pacific Northwest River Basin Commission *(1970)*, referenced in Sullivan and others *(1987)*.
[3]Nelson *(1974)*.
[4]Moore and Anderson *(1979)*.
[5]*Sullivan and others (1987)*.

(1) The suspended load at the Deschutes River's mouth between WY 1961 and WY 1973 probably averaged 25,000-32,000 t/yr *(Table 4-5)*, whichi is the range of estimates from two three-year and one two-year period;

(2) In WY 1978 *(Table 4-6)*, 83 percent of the river's load came from mainstem bank erosion up to RM 47, and 17 percent from tributaries. Thirty percent came from RM 2-RM 25, and 53 percent from RM 25-RM 47. Based on the results from this study about the relative amount of bank erosion in RM 25-41 versus RM 41-47, it is likely that most of this 53 percent came from RM 25-RM 41;

(3) *The river's sediment yield in the 1976-1987 was probably* greater than the rate during 1961-1973, based on the measured sediment load at RM 37 in this time period *(Table 4-5)*.

Table 4-6. Sources of suspended sediment in WY 1978, from Moore and Anderson *(1979)*.[1]

Source	Amount (t/yr)	Percent of Total
Mainstem banks RM 2-25	7,000	31
Mainstem banks RM 25-47	12,000	52
Tributaries[2]	3,900	17

[1]Scaled from November and December measurements to entire water year by comparison to flux measured at the mouth.
[2]Tributaries sampled by Moore and Anderson *(1979)* were Reichel Lake, Fall, Mitchell, Huckleberry, Johnson, Thurston, Lincoln, Lewis creeks, the Little Deschutes River and the Deschutes River above Lewis Creek, which together are believed to account for 95 percent of all sources outside of the mainstem below RM 47 ***(Moore and Anderson 1979)***.

These results compare well with bank erosion estimated from this study. This study estimated the contribution of mainstem bank erosion in RM 2-RM 41 to suspended load at the mouth to be 21,000 t/yr in 1941-1981 and 28,000 t/yr in 1981-1991 *(p. 52)*. If it is assumed that the 1978 source ratios *(Table 4-6)* are representative of other years, this study's estimates compares to suspended sediment study estimates of 21,000 t/yr-27,000 t/yr from 1961 to 1973 from banks downstream of RM 47, most of which is probably from downstream of RM 41. While the representativeness of the watershed source apportioning measured in 1978 is not known, nor is it known with confidence how large the total suspended load has been since the mid 1970s compared to the 1960s and early 1970s, the suspended sediment data serve to confirm the order of magnitude of this study's estimated bank erosion rate, and also to suggest that mainstem bank erosion in RM 2-41 produces about three to four times more suspended sediment than other watershed sources.

Comparison to Sediment Load in Similar Watersheds. The suspended sediment load of the Deschutes River is comparable to similar, nearby rivers. Sediment data are available from several river basins of comparable size having lowland reaches in glacial sediments and upper watersheds of forested bedrock terrane with relief comparable to the Deschutes. When expressed as a specific suspended sediment discharge, the Deschutes River at its mouth transported about 170 t/mi^2/yr in the 1960s and 1970s. By comparison, in the nearby Skookumchuck River at Centralia (drainage area of 61.7 mi^2), the specific yield was 130 t/mi^2 in the 1960s; the Newaukum River near Chehalis (drainage area 155 mi^2) in the same period had a specific yield of 240 t/mi^2/yr; the Satsop River at Satsop (drainage area 299 mi^2) had a specific yield of 790 t/mi^2/yr *(Glancy, 1971)*. These basin yields all reflect natural and human-caused sediment sources, as does that from the Deschutes River.

4.6 Chapter Summary

This chapter focused on describing the erosion rates, locations, and characteristics of eroding banks. Chapter 5 will focus on factors that cause or reduce bank erosion. Information on the volume, height, grain-size, and persistence of erosion sites developed in this chapter is useful for determining the appropriateness of potential erosion management measures at particular sites; this topic will be taken up in chapters 5 and 7.

Of 127 eroding banks identified by comparing 1981 and 1991 aerial photos, twenty-two (17 percent) were greater than 10,000 yd^3 in volume, and together accounted for half (53 percent) of mobilized sediment. Of these 22 sites, half are in RM 34-RM 40.5, and half in RM 4-RM 16. Most (81 percent) eroding banks are 10 ft or less in height and account for 60 percent of total volume. The 19 percent (24 sites) of eroding banks higher than 10 ft account for 40 percent of eroded volume. When viewed over a 50-yr time frame, the locations of many eroding banks are ephemeral or only periodically active, and about half of the 1981-1991 eroding banks are somewhat persistent through time.

Channel width has not increased systematically through time since 1941, although width has varied. It is possible the variation reflects a response to flood history, but the variability of width with position along the river is high relative to the amount of change, and trends are poorly defined.

These 127 sites mobilized 870,000 yd^3 of sediment between 1981 and 1991 (87,000 yd^3/yr), of which an estimated 350,000 yd^3 (35,000 yd^3/yr or 44,000 t/yr) is a sediment influx from teraces, and the remainder redeposits in the river system. Based on grain size of bank material, about 80 percent or 28,000 yd^3/yr (35,000 t/yr) is suspended sediment. The remaining 7,000 yd^3/yr (9,000 t/yr) is bedload. Erosion may have been less from 1941-1981, producing on average 21,000 yd^3/yr (26,000 t/yr) of suspended sediment influx and 5,000 yd^3/yr (6,000 t/yr) of bedload. Results of previous suspended sediment studies in the Deschutes River basin indicate suspended sediment yields of about 25,000-32,000 t/yr between 1961 and 1973, and that about 80 percent(or 21,000-27,000 t/yr) of this derives from mainstem bank erosion. This bank erosion contribution to the river's suspended sediment load, independently derived from suspended sediment data, substantiates the estimates in this study from photo-measured bank erosion (21,000-27,000 t/yr from suspended sediment data for 1961-1973 compared to 26,000 t/yr for 1941-1981 from this study).

Erosion in the Deschutes River is comparable to nearby basins with similar geology and relief. Specific sediment yield in the Deschutes River (130 $t/mi^2/yr$ in 1961-1973) is comparable to specific sediment discharges measured in the same time periods from nearby basins of 130 $t/mi^2/y$ in the Skookumchuck River and 240 $t/mi^2/y$ in the Newaukum River.

Bank erosion appears to have been greater in 1981-1991 than 1941-1981, although the measurement imprecision limits the confidence with which this can be concluded. If 1981-1991 erosion is greater than previously, it may reflect the effects of the record January 1990 flood, a correspondence explored further in Chapter 5.

5.0 FACTORS INFLUENCING CHANNEL EROSION AND MIGRATION

5.1 Geology and Topography

Geology and topography are the dominant factors influencing both the location and overall rate of bank erosion.

Presence of Glacial Terraces. Large sediment sources cluster in areas having glacial outwash terraces. The greatest concentration of large sediment sources ***(Figure 4-3)*** and high banks ***(Figure 4-4)*** are in reaches where there is a narrow valley between glacial terraces (RM 4-RM 10 and RM 34-RM 40). The presence of high and easily-erodible terraces is the primary reason that bank erosion along the Deschutes River produces a net sediment influx.

The Deschutes River in the study reach has been in disequilibrium since deglaciation in the sense that more sediment has been eroded from it than has been transported into it from upstream as the river has incised and widened its valley into the outwash. Church and Slaymaker ***(1989)*** and Slaymaker ***(1993)*** have pointed out this is a common situation in glaciated, lowland portions of western British Columbia. Comparable situations also occur in several other Puget Lowland rivers including the Cedar River, a tributary to Lake Washington, which also erodes most of its sediment from lowland terraces of glacial outwash ***(King County Department of Public Works 1993)***. The White River, tributary to the Puyallup River, is a geologically different but analagous situation. In the last 6,000 yr the river has been cutting a canyon upstream of the town of Auburn ***(Dunne 1986)*** through deposits of the massive Osceola mudflow from an eruption of Mt. Rainier ***(Mullineaux 1970)***.

Because of this geologic setting, the spatial pattern of sediment production in the Deschutes River drainage differs from that in more typical forested, mountainous terrain in which landslide erosion in the steep headwaters dominates watershed sediment production. While some sediment is produced in the headwaters of the Deschutes River basin ***(Chapter 3)***, much more is produced in the lower basin ***(Chapter 4)***.

An understanding of the overall geologic influence on sediment production in the basin is important for planning purposes, because while human actions may have increased the rate, a high rate of mainstem erosion is natural, and plays a role in the natural functioning of the riverine ecosystem. For example, mainstem bank erosion is the primary source of spawning gravel in the anadromous reach of the river, especially in the lower river, because even if landsliding were more intense in tributary streams, very little landslide-derived sediment would make it to the lower river because of the effects of attrition and local aggradation. An appreciation of the geologic influence on erosion is also important from a planning perspective, because it provides context for developing a plan to reduce erosion by indicating reaches or bends in which the process of valley widening is particularly dynamic, where it may be prohibitively difficult or expensive to slow the rate of erosion.

Variation in Channel Gradient. Most but not all of the reaches in which bank erosion sites cluster also correspond with areas of declining stream gradient ***(Figure 5-1)***. This is because where the channel gradient declines, gravel bedload deposits in bars, and the bars tend to cause the flow to shift laterally toward the bank. Areas of less bank erosion correspond to reaches in which the channel gradient increases in a downstream direction, or is roughly constant.

5.2 Riparian Vegetation and Land Use

The presence of outwash terraces, the valley width, and declining stream gradient together are the dominant controls on the rates and locations of erosion. However, land use has also played a secondary role in localizing erosion.

Inventory of Riparian Vegetation

On aerial photos from 1941 to 1991 we mapped the vegetation and land use within 300 ft of the channel. For forested banks, we used the method in the state of Washington's Watershed Analysis procedure ***(Washington Forest Practices Board 1993)***. Table

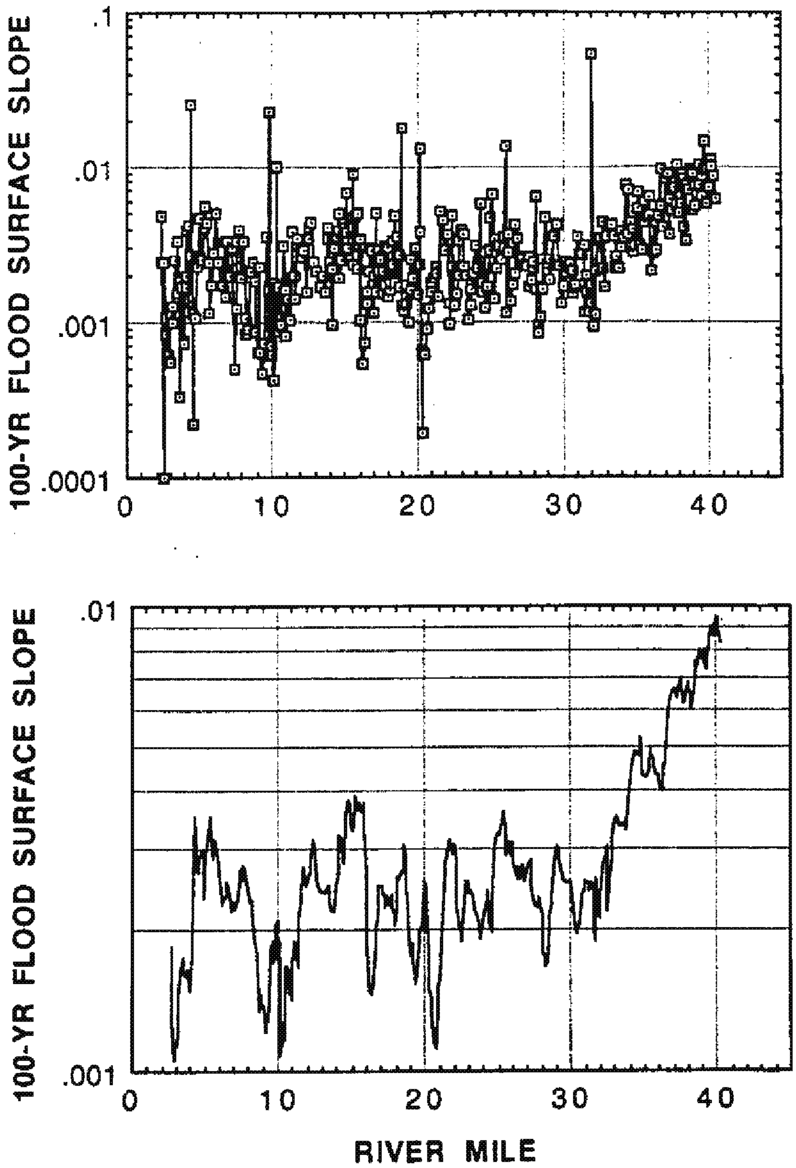

Figure 5-1. (A) Water-surface slope during the 100-yr flood, from model profiles computed from detailed channel surveys in 1977 (FEMA 1982; 1984). The water surface slope is used because it is a primary influence on the intensity of sediment transport. (B) Nine-point running average, which provides a smoothed graph for interpreting changes in gradient along the channel.

10-6 gives detailed description of map units. A vegetative buffer (a band of forest less than 300-ft wide, between the river and landward non-forest cover) occurred immediately adjacent to the river along 48 percent of its length in 1991 *(Table 5-1)*. Upland-contiguous forest lined an additional 44 percent of the river's length. Pastureland with no riparian vegetation was next in prevalence (4.0 percent of total length), followed by lawn (2.1 percent), shrub (1.6 percent), road (0.4 percent) and industrial areas (0.3 percent).

Table 5-1. Land use/vegetation type adjacent to the Deschutes River in 1991, RM 2-RM 41, as interpreted from aerial photographs. For explanation of categories see Table 10-6.

Cover Type	Length (feet)						
		Forest Type					
	Total	Immature		Mature		Old	
		Sparse	Dense	Sparse	Dense	Sparse	Dense
Industrial	1,200						
Road	1,825						
Shrub	7,000						
Lawn	9,125						
Pasture	17,500						
Forest	190,725						
(conifer)	80,375	4,400	22,975	4,075	48,125	0	800
(mixed)	69,375	2,725	11,650	7,300	47,700	0	0
(deciduous)	40,975	2,000	14,275	2,325	22,375	0	0
Buffer	208,325						
(conifer)	17,975	0	1,175	800	16,000	0	0
(mixed)	84,900	350	2,450	6,350	75,750	0	0
(deciduous)	105,450	2,000	27,525	12,575	63,350	0	0
TOTAL	435,750						

Within the forested riparian areas, 42 percent was conifer dominated, 36 percent mixed conifer and deciduous, and 22 percent deciduous *(Table 5-1)*. For all species composition types, 30 percent of the riparian forest cover was immature, 70 percent mature, and less than half a percent (one 800-foot length) was determined from aerial photos to be old. Most of the riparian mapped "buffer" was deciduous (51 percent), followed by 41 percent mixed and 9 percent conifer. For all buffer species composition types combined, 16 percent was immature and 84 percent mature *(Table 5-1)*. Table 10-6 summarizes the riparian vegetation and land use in detail from 1941 through 1991.

Table 5-2 indicates the incidence of eroding banks relative to the proportion of various land uses along the river. The last column in the table indicates whether particular land uses account disproportionately for eroding banks. It indicates that forest and buffer land types, the two dominant land uses, account for roughly representative numbers of eroding banks, although there are slightly more erosion sites in immature forests than in mature forests. Among the other land uses, industrial and road sites account for too little land to make any conclusions about their importance. Eroding banks in shrubby riparian vegetation may be disproportionately represented, but the number of sites (four) is too small to draw conclusions.

Table 5-2. Percent of eroding sites in various vegetation cover types compared to lineal percent of cover types in 1991.

Cover Type	Percent of River Length	Percent of Eroding Sites	Ratio of Percent of Eroding Sites to Percent of River Length
Industrial	0.3	0.	0.
Road	0.4	1.6	4.0
Shrub	1.6	3.1	1.9
Lawn	2.1	0.8	0.4
Pasture	4.	13.	3.3
Forest	44.	43.	1.0
(Immature)	(13.)	(16.5)	(1.3)
(Mature)	(30.)	(26.8)	(0.9)
Buffer	48.	39.	0.8
(Immature)	(7.7)	(7.9)	(1.0)
(Mature)	(40.)	(30.7)	(0.8)

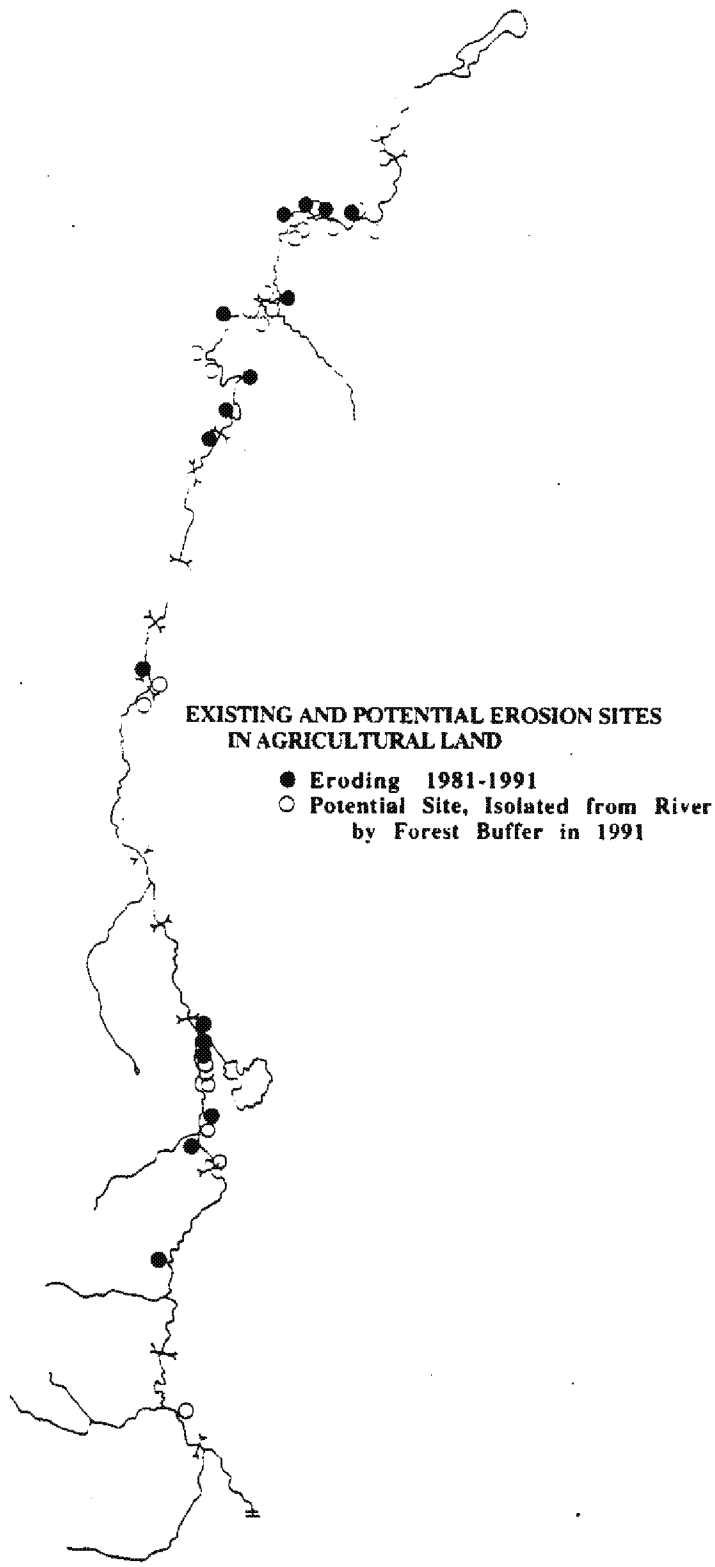

Figure 5-2. Map of 1981-1991 eroding sites bordered by pasture lands without riparian vegetation, and eroding sites where pasture is separated from the river by a forested buffer.

Agricultural Lands Lacking Riparian Vegetation. The number of eroding banks in pasture without riparian vegetation ***(Figure 5-2)*** account for a significant portion of the total erosion sites (16 of 127 or 13 percent) and is disproportionate to the occurrence of pasture, which is found along 4.0 percent of the river length. Table 5-2 indicates that erosion sites are 3.3 times more common than the occurrence of riparian pasture. In the field, the lack of riparian forest appeared to promote the undercutting and caving of banks by the river, although the roots would be ineffectual on higher banks, as discussed below.

The importance of this land use is potentially even greater if a longer time frame is considered. Of the 49 sites having a "buffer" land use, 18 of these have "pasture" as the landward use ***(Table 5-3; summarized from Tables 10-3 and 10-6)***. In many of these cases the buffer is narrow, and subject to lateral channel erosion, so that some of these sites will probably in the future also become subject to erosion with no protection by riparian vegetation.

Table 5-3. Land-use type landward of forest "buffer" at 1981-1991 eroding sites.

Total Buffer Sites	Land Use Type Landward of Buffer					
	Shrub	Lawn	Industrial	Road	Pasture	Forest
49	9	2	1	14	18	5

Destabilizing Effects of Logging the Native Riparian Forest. Early logging of the mature riparian forest, which for the most part occurred prior to the 1941 photos, may have played a role in destabilizing banks. This is mostly true on shorter banks, in which tree roots are more effective at resisting erosion. Field observations of the occasional stream bank "old growth" tree indicated that roots of these trees on shorter, floodplain banks significantly protected banks from erosion. Various studies have documented the effects of riparian vegetation removal on promoting bank erosion ***(Kondolf*** *and Curry 1986; Roberts and Church 1986; Madej and others 1992).* In addition, when large trees would have fallen into the river, they would have provided substantial bank protection, and would have been more stable than the smaller trees now in the river.

If this has been an important factor, it could explain the apparent (but weakly-defined) overall increase in the number of erosion sites through time, particularly in the upstream reach. It is possible that the effects of riparian logging could be expressed in the spatial pattern of increase in erosion sites with time in the upper six river miles, which differed from that in downstream reaches shown in Figure 4-7. The original riparian forest, excepting one mile-long reach between Johnson and Mitchell creeks (Section 8, Township 15N, Range 3E) which had been cut down prior to 1941, was mostly logged upstream of RM 34 in the 1941-1954 and 1954-1966 periods, while it had been mostly logged prior to 1941 in the downstream reaches.

However, trees are relatively ineffectual in protecting most terraces from erosion, because the rooting depth of trees is above the slope toe where river flow erodes and undercuts the slope, especially on the highest terracees, and most erosion comes from these terraces *(Table 4-1).* As indicated in Chapter 4, 19 percent of eroding banks are higher than 10 ft and account for 40 percent of volume. Trees would not be expected to be effective at protecting these slopes. Mature trees are likely to slow erosion on banks less than 6 ft, which account for 40 percent of sites and 27 percent of erosion. Mature tree roots on banks between 6 and 10 ft high, which account for 41 percent of sites and about 33 percent of total erosion, in some cases might protect or partially protect banks, but data was not collected to evaluate this in detail.

In summary, logging of original mature riparian forest may have caused some increase in erosion, with the importance of such logging being generally proportional to bank height. The importance of this effect could not be quantified. For this reason the benefit to bank stability of restoring mature riparian forest cannot be quantified. It can be said that the potential to moderate the rate of bank erosion by restoring mature forest to banks not now having mature forest is also generally proportional to bank height, neglecting other site factors such as the intensity of erosive force, which is related to bend sharpness *(Hickin and Nanson 1975)* among other factors.

Potential Hydrologic Influences of Land Use on High Bank Stability. Although the detailed site analysis necessary to evaluate this effect was not undertaken as part of this study, there is the potential that at some of the higher terrace erosion sites, land use could have influenced groundwater conditions, which could influence the terrace slope stability. This effect was not evaluated in the study, and is brought up in Section 7 in connection with additional information needed for planning purposes.

5.3 Artificial Bank Protection

Bank protection was mapped in river segments that were field visited ***(Table 5-4; Figures 5-3 and 10-1).*** Artificial bank protection, which included large rock or concrete fragments, cemented tires, and concrete bulkheads, was present on 14,700 feet (2.8 miles) of the river's left bank, or 10.6 percent of the surveyed length. Bank protection was present on 10,800 feet (2.0 miles) of the river's right bank, or 7.8 percent of the surveyed length (26.3 miles).

Riprap has probably reduced erosion at a number of sites in the fifty years between 1941 and 1991, although this study did not include the detailed, site specific analysis of riprap history and channel bend evolution that would be needed to confirm this. Within the reaches in which we field-mapped riprap, there are eleven sites now riprapped where the banks actively eroded at some time in the photo record, but are now stable ***(Table 5-5).*** Some of these sites may or may not have stabilized without the application of bank protection, since the pattern of bank erosion throughout the 50-yr period is sporadic or short-term at many sites ***(Table 4-3)*** because the river's planform shape changes through time in reaches of active river migration. An additional site was active in the 81-91 time period, but was riprapped in 1993 ***(Table 5-5).***

Taken together, if it is assumed that all 12 of these sites were stabilized by riprap, and that all would have remained active throughout the study period, and projecting their average erosion rates prior to stabilization, about 4,000 yd^3/yr of erosion would have been avoided at these sites. Both assumptions make this an overestimate. An additional 8-10 sites ***(Figures 5-3 and 10-1)*** remain active, but have had riprap in some part of their length, which may have reduced the length of eroding bank. Riprap is also

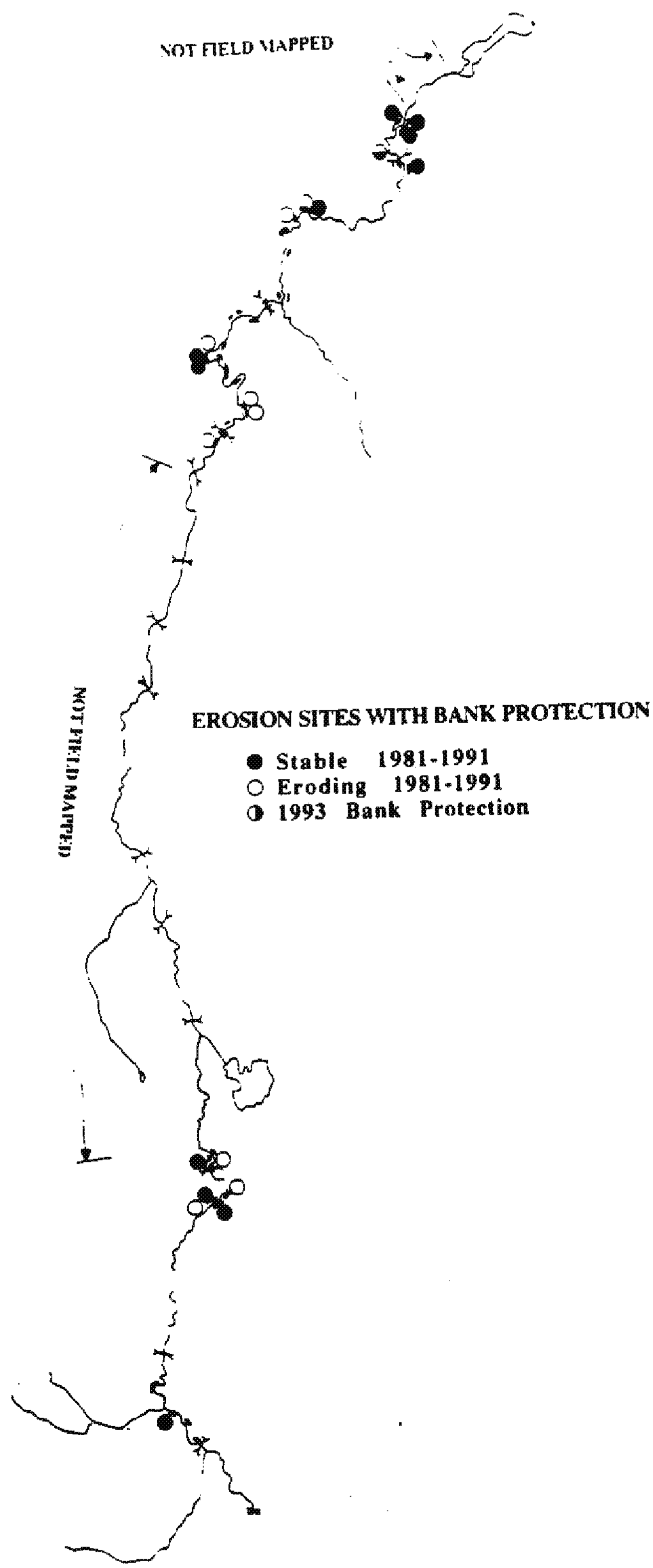

Figure 5-3. Generalized map of riprap in field-mapped reaches (detailed mapping is in Figure 10-1), and sites at which riprap may have played a role in stopping or partially limiting erosion.

Table 5-4. Distances of streambank with bank protection, as noted in field survey in 1993. Segments are from McNicholas *(1984)*. Segments and bank protection are shown in Figure 10-1 maps.

Segment Number	River Miles	Segment Length (ft)	1993 Riprap Length LB (ft)	RB (ft)
1	2.0-2.7	3900		
2	2.7-4.5	9500	1700	1650
3	4.5-5.5	5280	500	450
4	5.5-6.4	4750	0	0
5	6.4-7.0	3200	0	0
6	7.0-7.5	2640	0	0
7	7.5-7.9	1800	950	0
8	7.9-8.2	1500	900	0
9	8.2-8.5	1800	900	0
10	8.5-9.0	2640	0	300
11	9.0-9.2	1050	0	0
12	9.2-9.6	1850	100	100
13	9.6-10.0	2400	100	100
14	10.0-10.2	1000	100	100
15	10.2-10.5	1575	500	1100
16	10.5-11.1	3400	200	0
17	11.1-12.2	6000	0	450
18	12.2-13.1	4800	1000	1100
19	13.1-14.0	4900	900	0
20	14.0-14.6	3200	0	800
21	14.6-15.1	2400	250	100
22	15.1-16.1	4750	350	50
23	16.1-19.5	18000		
24	19.5-20.8	6900		
25	20.8-21.9	5750		
26	21.9-22.8	4750		
27	22.8-25.0	11600		
28	25.0-26.5	7900		
29	26.5-28.5	10500		
30	28.5-29.8	6600		
31	29.8-31.5	8975		
32	31.5-32.7	6600	1700	800
33	32.7-33.6	4750	3400	3300
34	33.6-34.7	5800	0	0
35	34.7-35.7	5000	0	0
36	35.7-36.6	5000	0	0
37	36.6-37.5	4750	0	0
38	37.5-38.5	5280	1150	0
39	38.5-39.3	4200	0	400
40	39.3-39.8	2600	0	0
41	39.8-40.2	2100	0	0
42	40.2-40.7	2650		
TOTAL		204,040	14,700	10,800

Table 5-5. Sites where riprap bank protection may have stopped or partially stopped bank erosion.

Most Recent Period of Erosion	Sites not Active in 1981-91	Sites Active in 1981-91, Partially Riprapped	Sites Riprapped in 1993
1941-1953/54	108, 109, 320		
1953-1965/66	538, 539, 1028, 1055		
1965/66-1972	107, 1060, 1278		
1972-1981	134		
1981-1991		330, 350, 379, 500, 605, 620 670, 1025, 1040, 1068	120

present in a few additional sites that were not active enough in the past, if at all, to be observed by the photo measurements or either field survey. Some of these may be sites where erosion could become more active as the river planform shape changes locally through time.

The effects of mechanical bank protection on bed morphology are unclear. A study from the Sacramento River ***(Buer and others 1989)*** observed that bank revetment caused channel narrowing and deepening. However, another study of the Sacramento River ***(Harvey and Watson 1989)*** comes to different conclusions. Neither study is extensively documented in published form or peer-reviewed and it is not clear what to conclude from them. Observations made in this study from one reach in the Deschutes River presented in Chapter 6 are consistent with riprap's having an effect on cross section shape, but are far from conclusive, and the issue needs systematic study, some discussion of which is presented in Chapter 7.

Bank protection can otherwise affect salmonid habitat and riverine function, including reducing spawning gravel supply, riparian shading and wood recruitment, and isolating off-channel habitat from the river. These issues will be discussed in Section 7.

5.4 Large Woody Debris

As part of the field survey, at 87 of 134 sites, observations were made of the effects on bank erosion of trees in streams with their root balls attached, or large portions of tree stems, collectively termed "large woody debris" ***(Bisson and others 1987)*** abbreviated as "LWD" or referred to as 'wood" in this discussion. Of the 87 sites, 74 had some amount of wood present, where on average it was in contact with 23 percent of the lineal distance of eroding bank ***(Table 5-6)***. In 38 of these 74 cases, where wood was in contact with an average 42 percent of lineal site length, wood was observed to be mitigating erosion, and in 2 cases wood was judged to be playing an aggravating role. In the 34 cases where wood was not noted to have an effect, wood was in contact with 14 lineal percent of the site. Wood was observed to protect banks from stream flow in cases where it was positioned parallel to the bank, and also to protect sloughing bank material from being carried away by the stream and in some cases promoting deposition of stream sediments between wood and bank, thus promoting soil stability needed for vegetative stabilization.

Table 5-6. Number of eroding sites where wood was observed to mitigate or aggravate erosion, or to have no apparent effect. Total sample size of sites where observations were made is 89.

Total Having Wood Present		Mitigating		Aggravating		No Effect Noted	
Number	Percent Lineal Contact	Number	Percent Lineal Contact	Number	Percent Lineal Contact	Number	Percent Lineal Contact
74	23%	38	42%	2	-	34	14%

As discussed above, live, standing mature trees on banks may also have an important stabilizing effect on shorter banks, and provide important shading and cover influences on aquatic habitat ***(Beschta and others 1987)***. Once in channels, wood provides important habitat ***(Bisson and others 1987)***. All of these functions, along with the apparent bank-protection benefits of wood, together point toward the benefit of retaining wood in the system, and restoring mature trees to riparian banks. This issue will be discussed in Section 7.

5.5 Floods and Watershed Land Use

Flood History. The rate of bank erosion is presumed to correspond in a general way with the size of flood events in the Deschutes River because of this correspondence in other rivers. If a general correspondence is hypothesized between the amount of bank erosion in photo periods and flood sizes, then this would be supported by the fact that bank erosion in the 1981-1991 period was apparently greater than in previous periods ***(Figure 4-7)***, and this period also included, in 1990, the largest flood on record at the Rainier gage (1950-1992) as well as the fourth largest flood on record, in 1991. As well, erosion in the 1941-1953 period was apparently less than in succeeding periods, and there were no floods from 1946-1953 exceeding a 5-yr flood. While there is no flood record on the Deschutes River prior to 1946, there are no floods in excess of a 10-yr recurrence on the nearby Mashel and Nisqually rivers ***(Williams and Pearson 1985)***. On the other hand, the 1972-1981 period, which contained the second largest flood on record in 1974 ***(Figure 2-3)***, apparently had the second lowest rate of erosion ***(Figure 4-7)***, although the 1965-1972 period, which had an event nearly as large, does indicate a high erosion rate, and there is not a great deal of difference among the three periods between 1953 and 1981.

This non-conclusive relation between bank erosion amount and large floods may in part be due to the measurement error involved in photo measurements made in this study. The error is probably greater in the 1941-1954 period than in later periods, because the 1941 and 1954 photos were smaller in scale, and had less resolution than later photographs used. In general, the measurement uncertainty, although poorly defined, was estimated ***(Section 4)*** for individual measurements to be as great as 25 to 100 percent.

It is possible that our results indicate that erosion was significantly greater in 1981-1991 than in previous periods, and that this difference relates to the size of the 1990 flood, but the large measurement error limits the confidence with which this conclusion can be drawn. It might be possible to refine the precision of bank erosion estimates using a more precise measurement of bank erosion, which could be made using a GIS-based system rather than the approach used in this study. It would also be possible to collect anecdotal information or measurements that would describe the intensity of bank erosion from the 1990 and previous large storms, and would help to further interpret the effects of large floods.

Land Use Effects on Floods. The existing data on erosion since 1941 ***(Figure 4-7)*** do not indicate a systematic increase in rate through time, nor can the flood record ***(Figure 2-2)*** be interpreted to indicate an overall increase in the size of floods through time, so that neither point toward a change through time in a land-use effect on flooding and erosion. However, it is still valuable to evaluate existing studies of land management effects on floods in the basin, to determine whether it is likely that there could be such an effect, which would help to indicate whether it is warranted to refine estimates of how bank erosion rates have changed through time for the purpose of further evaluating any connection between land use, flooding, and bank erosion.

Research on flooding and forest management has focused on the effects of vegetative change on the augmentation of rain and snow-melt, or "rain-on-snow" events ***(Coffin and Harr 1992; Harr 1983)***, and this is currently the primary focus of the hydrologic change module of Washington state's Watershed Analysis methodology ***(Washington Forest Practices Board 1993)***. While this effect has been observed on a small-watershed scale, it has not yet been detected from available streamflow records from large regional watersheds of the scale of the Deschutes River ***(Toth 1991b; Duncan 1986; Cundy 1993)***. This is because detection of an effect on a large basin scale is hindered by the imprecision and short period of gage records, and also because the effects of floodplain storage on flood routing begin to dominate flood characteristics in large basins.

The Deschutes River basin is mostly within the rain-dominated elevation range ***(Brunengo and others 1992)***. In addition, observations of the 1990 flood event indicated that it was not primarily a rain-on-snow event *(Toth 1991a)*. However, no systematic model evaluation has been made of the potential for past flood events in the Deschutes River basin to have been influenced by rain-on-snow augmentation in clearcuts. A previous study *(McNicholas 1984)* used a model approach to indicate dramatic increases in flood sizes from logging. However, the study used the SCS Runoff Curve approach, which was developed for use in small agricultural catchments *(Dunne and Leopold 1978)*, and is not appropriate for use on watersheds as large as the Deschutes.

Duncan *(1986; also reported in Sullivan and others 1987)* analyzed the streamflow record from the Deschutes River and did not find a systematic increase through time in flood peaks relative to precipitation. However, as indicated above, the analysis did not determine what storms have been rain-on-snow influenced, and only evaluated the rainfall-runoff record for a monotonic increase through time. Any effect of timber harvest might vary in a non-monotonic way with time along with the change in hydrologic immaturity. The study also had available streamflow data through 1980. A more conclusive study could now be done using methods available for modeling individual rain-on-snow storms, in conjunction with streamflow data from a longer period of record.

A second effect that forest management may have on runoff is that of a dense network of forest roads, which can increase the effective drainage area of streams, which may increase the time to peak of floods. However, initial studies of this effect are only now being conducted, and the effect is not well established or understood. It may be possible to evaluate whether this effect is important in the Deschutes River basin within a few years as research efforts develop.

5.6 Tributary Coarse Sediment Influx

The possibility exists that bedload from tributary streams deposits in the study reach, causing bank erosion. Such an effect has been noted in headwater streams of mountainous watersheds which undergo an increase in landsliding from a large storm, logging and logging roads, or a combination of the two *(for example Beschta 1983)*, or as a result of large fires, earthquakes or other possible causes of an increase in sediment production.

The amount of bedload contributed to the study reach was estimated *(Chapter 3)* to be roughly a thousand cubic yards per year. This is small compared to the scale of the Deschutes River in the upper study reach downstream of the Falls, where individual gravel bars and eroding banks are typically an order of magnitude larger than the estimated total tributary input. If the estimate of tributary bedload from Chapter 3 is mistakenly small, and is closer to, say 2,000 yd^3/yr, this is still not large compared to the scale of erosion and transport in the upper study reach. If the rate were as high as 2,000 yd^3/yr, this would also indicate that most tributary bedload is natural, because landslides from logging and road building were quantified as several hundred cubic yards per year.

It can be said with even more confidence about the lower portion of the study reach that tributary coarse sediment influx does not primarily cause mainstem bank erosion, because tributary bedload (all of which originates upstream of RM 35) would be cut in volume by about half or three-quarters by the effects of attrition in transport down the Deschutes River by the time it arrived in the lower reach *(Chapter 3)*. Moreover, any logging- or road-related landsliding, which did not occur prior to 1966, is not likely to have yet arrived in the lower river.

It is likely that there have been local effects of tributary input on bank erosion, such as that prior to 1941 from bank erosion in the Mitchell Creek watershed, which appears on the 1941 photos possibly to have influenced channel morphology and possibly bank erosion in the immediate vicinity of the confluence. However, in general tributary influx does not appear from aerial photos to have had a systematic or quantitatively significant overall effect on bank erosion in the study reach.

5.7 Chapter Summary

The presence of glacial outwash terraces in a narrow river valley, and locally-declining river gradient are the dominant influences on the rate and locations of sediment influx from terrace erosion along the Deschutes River. Bank erosion along the Deschutes River is a "natural" and ecologically important process that would occur in the absence of land use.

However, riparian land use probably has increased erosion somewhat over the natural rate. This is especially true on easily-erodible agricultural lands lacking riparian vegetation, as suggested by the disproportionate number of erosion sites accounted for by this land use. Restoration of mature riparian forest could moderate erosion at some of these sites, primarily on lower banks where tree roots are more effective. Logging of native riparian forest, most of which occurred prior to the first aerial photos in 1941, may have had a role in increasing the rate of erosion over that in the river's undisturbed condition, primarily along shorter banks, but this is speculative. Riparian land use has the potential to affect groundwater and slope stability of some high terraces, but this was not evaluated in this study.

Mature trees that had fallen into the river appeared to protect banks from erosion.

Bank protection is present along about 10.6 and 7.8 percent of the river's right and left banks, respectively, in the 26.3 RM that were field mapped. Riprap may have stopped erosion at about 12 sites, and may have reduced the length of eroding bank at an additional 8-10 sites. Riprap can limit riverine function because it can cut off the river's primary source of spawning gravels, reduce shading and wood recruitment, isolate off-channel habitat, and possibly affect channel cross-sectional form. The ephemeral nature of erosion sites in the Deschutes River also indicates that local riprap use could lead to the need for progressive installation upstream and downstream, aggravating ecosystem effects.

There is not evidence in the 50-yr record of bank erosion and floods to indicate that hydrologic effects of headwater timber harvest have increased the intensity of flooding and bank erosion. This issue could possibly be determined with more certainty with a new runoff study that makes use of data and methods now available, and possibly a more precise approach to measuring historic bank erosion than was used in this study. It is not at this time possible to assess the hydrologic effects of the forest-road network on basin hydrology.

The supply of coarse sediment from landsliding and bank erosion in tributaries, as estimated in Chapter 3, is small relative to the scale of erosion and sediment storage in the study reach, and is not a primary cause of mainstem bank erosion.

6.0 CHANNEL AGGRADATION

6.1 Approach

Because erosion of gravelly terraces introduces a net influx of bedload to the river, it is reasonable to expect that some of this material may be depositing in some reaches more rapidly than it is being exported, causing net long-term deposition, or aggradation. To assess channel aggradation, we resurveyed in 1993 cross sections originally surveyed in 1977 as part of a flood study *(FEMA 1982; 1984)*. The 1977 study included 343 cross sections between RM 2.3 and RM 40.5. It was not planned in this study to resurvey all of these cross sections, but instead to survey some of them to evaluate the efficacy of the approach, and to develop information that could potentially be extrapolated to other reaches.

To guide our choice of reaches in which to resurvey cross sections as well as to inform our extrapolation of the results to other reaches, we constructed a simple qualitative rating of reach aggradation potential. The qualitative rating is based on whether the reach is declining in gradient *(from Figure 5-1)*, whether there is a significant source of coarse sediment within that reach or immediately upstream of it *(from Figure 4-3B)*, and whether the river is relatively confined by its valley, from topographic maps. Reaches are rated in Table 6-1. About 10 river miles of the 39 studied (one-fourth) were rated as potentially susceptible to aggradation.

Two reaches were selected for detailed study: (1) a 1.5-mile-long reach immediately upstream of the Tumwater city limits (RM 3.3 to RM 4.8, including the Henderson Boulevard bridge at RM 4.5); and (2) RM 31.1 to RM 33.7, a 2.6-mile-long reach upstream of Lake Lawrence having a high density of housing. The upstream reach was in an area of declining gradient. Both reaches contain or are downstream of coarse sediment sources. Flooding has been identified as a concern in both reaches, which are bordered by diverse and intensive land uses, and this was also considered in choosing the reaches.

The 1977 cross sections were surveyed by the U.S. Geological Survey (USGS) under contract to the Federal Emergency Management Agency (FEMA) as part of the development of flood insurance rate maps by a FEMA contractor. The cross section data were available in a computer file stored on microfiche at FEMA's Bothel, Washington

Table 6-1. Qualitative aggradation-potential rankings for reaches of the Deschutes River between RM 2 and RM 41. A reach was rated as having aggradation potential if the gradient was declining, channel was unconfined, and there was a source of coarse sediment within the reach or within a few miles upstream.

Reach River Mile	Declining Gradient?	Channel Not Confined?	Coarse Sediment Source?	Aggradation Potential
2 - 4		+	+	
4 - 4.5	+			
4.5 - 10		±	+	
10 - 12.5	+	+	+	+
12.5 - 14		+	+	
14 - 14.8	+		+	
14.8 - 16		+	+	
16 - 19	+	+		
19 - 21			+	
21 - 22	+		+	
22 - 23			+	
23 - 28.1		+		
28.1 - 29	+	+		
29 - 30		+		
30 - 34	+	+	+	+
34 - 36			+	
36 - 37	+	+	+	+
37 - 38			+	
38 - 39.6	+	+	+	+
39.6 - 40	+		+	
40 - 40.6	+	+	+	+

office. The cross sections were not field monumented in 1977, and FEMA's mapping contractor could not provide field notes for the cross sections, which would have assisted in field-locating them.

However, topographic maps were obtained having a scale of 1 inch to 400 feet, which showed the cross section locations in 1977. According to USGS personnel who conducted the field survey, the map locations reflect the cross sections' actual field locations, and so we used these maps in the field to guide our best estimate of the original cross section location. The precision with which we could field-locate the cross sections varied with the distance between a given cross section and a reliable landmark, such as a bridge. Establishment of the 1993 cross sections was often probably ±10 ft upstream or downstream of the original cross section, but in some cases may have been as much as ±40 ft. Fifteen cross sections were surveyed in the lower reach, and 23 in the upper reach; these data are in Table 10-7.

After we surveyed the cross sections, it was necessary to match the older and newer cross sections along the axis perpendicular to the channel in order to determine channel change. We estimated the cross section locations along the perpendicular axis by use of channel and bank morphology, riprap, trees, and other features noted in our field survey notes. We then revisited the channel cross sections to help resolve uncertainties in comparing the cross sections. In some cases, discrepancies or uncertainties could be accounted for by the greater horizontal distance between survey elevations in the 1977 cross sections compared to the 1993 cross sections, and it was appropriate to infer detail on the 1977 cross section based on the 1993 data. In other cases it was not possible to resolve discrepancies, and these cross sections were excluded from the analysis.

6.2 1977-1993 Cross Section Changes

Upstream Reach. Figure 6-1A shows the change in cross sectional area of channel-stored sediment at 16 cross sections in the upstream reach (RM 31.1-RM 33.7); a total of 23 cross sections were resurveyed, but 7 of these were not used because of uncertainties in comparing the 1977 and 1993 cross sections. A positive change in the figure represents net deposition, and a negative change indicates net scour. These 16 cross sections taken together indicate deposition between 1977 and 1993; total deposition is about 13,000 yd^3 over a 2.1-mile-long reach, or 400 yd^3/mi/yr when averaged over the 15 years between 1977 and 1993.

One of these cross sections ***(see Figure 6-1A)*** included a bar that appeared to have been mined, and the bar portion of the cross section was excluded from the computation of sediment storage change because the change is due to mining, rather than scour. If the bar portion of this cross section were included in the computation, then estimated deposition in the 2.1-mile-long reach would be 4,500 yd^3 (100 yd^3/mi/yr). The two cross sections downstream of the mining also showed a net lowering. *It is possible that lowering at* these sites is due to gravel mining at the bar, which could cause downstream degradation by reducing the downstream supply of

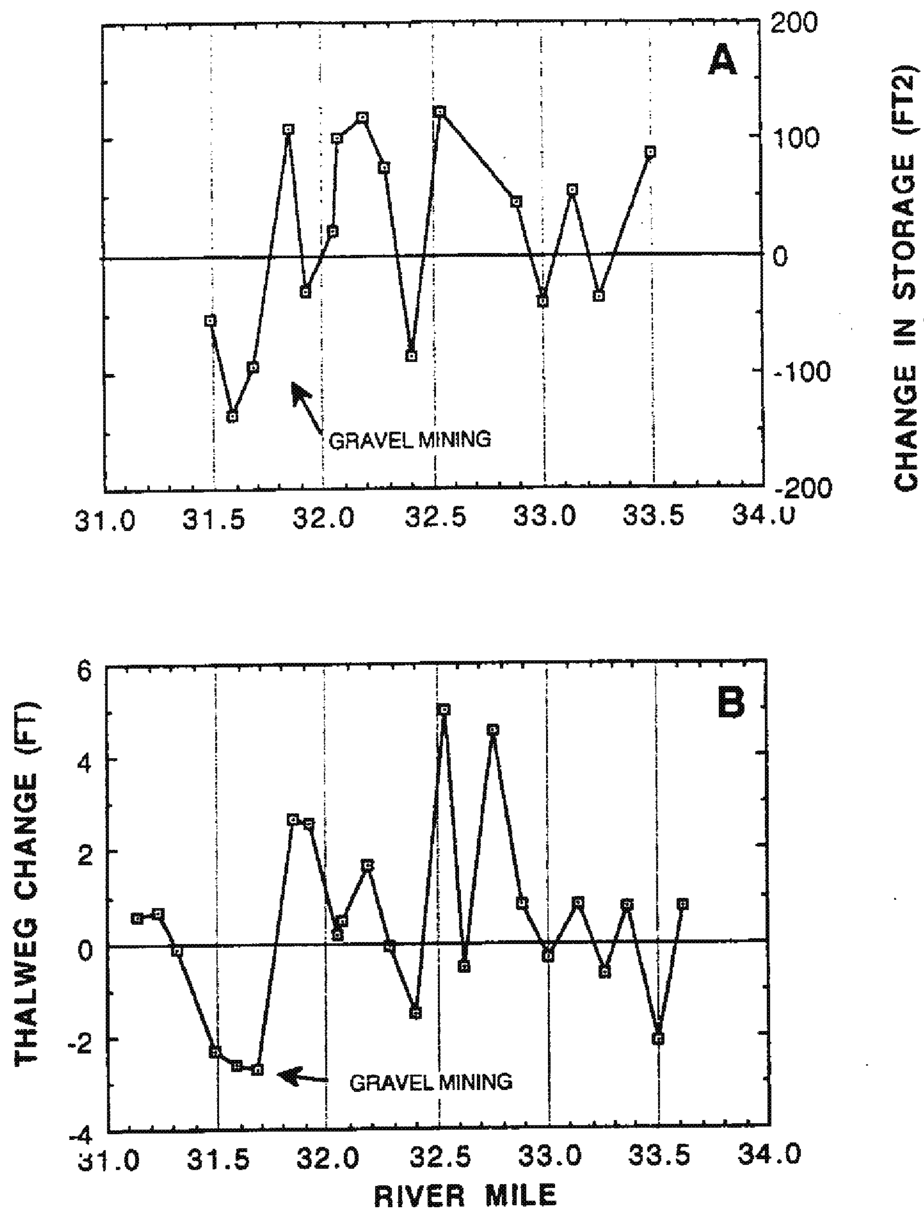

Figure 6-1. (A) Change in channel sediment storage, 1977-1993, at sixteen locations between RM 31.5 and RM 33.5. (B) Change in channel thalweg, 1977-1993, at 23 locations between RM 31.1 and RM 33.6.

gravel *(for discussion, see Collins 1994).* However, to evaluate this interpretation it would be necessary to know how much material has been mined from this bar in the past 15 years, to survey additional cross sections downstream, and to make a complete analysis of channel modifications in the reach. (Gravel mining would also tend to destabilize the right-bank slope atop which two houses are located, because scour would undercut the slope, and also because reshaping the bar could focus the river during floodflows on the embankment beneath the houses. However, this too cannot be evaluated without more information than was gathered as part of this study.) Setting aside the three cross sections potentially affected by gravel mining (JF, JE, and JD in Table 10-7), the total deposition would be 19,000 yd^3 (1,300 yd^3/yr) over a 1.8-mile-long reach, or 700 yd^3/mi/yr.

Depending on how the apparently mining-affected subreach is treated, the cross sections indicate the reach has experienced 100-700 yd^3/mi/yr of deposition in the past 15 years. This is a rough estimate of the change in channel-stored sediment because: (1) the 1993 cross sections could not be located exactly at the 1977 cross section sites; (2) elevations along some of the 1977 cross sections were widely spaced and channel banks were sometimes poorly defined, as indicated above; (3) a small number of cross sections were resurveyed; (4) matching the cross sections along the axis perpendicular to the channel was approximate.

Figure 6-1B shows the thalweg (lowest point in the channel cross section) elevations of the entire 23 cross sections in this reach, including the 7 at which the area change could not be confidently compared. The thalweg changes confirm the general trend toward aggradation that was indicated by the area changes in the previous figure. The thalweg profile also includes three points downstream of the lowermost point in Figure 6-1A. These additional downstream measurement points indicate aggradation, which is consistent with an interpretation that gravel bar mining could be causing degradation for a discrete distance downstream of the mined bar. However, more information is needed to evaluate this interpretation, as indicated previously.

Downstream Reach. Figure 6-2A shows change in cross-sectional area at 13 locations in the reach between RM 3.3 and RM 4.8.

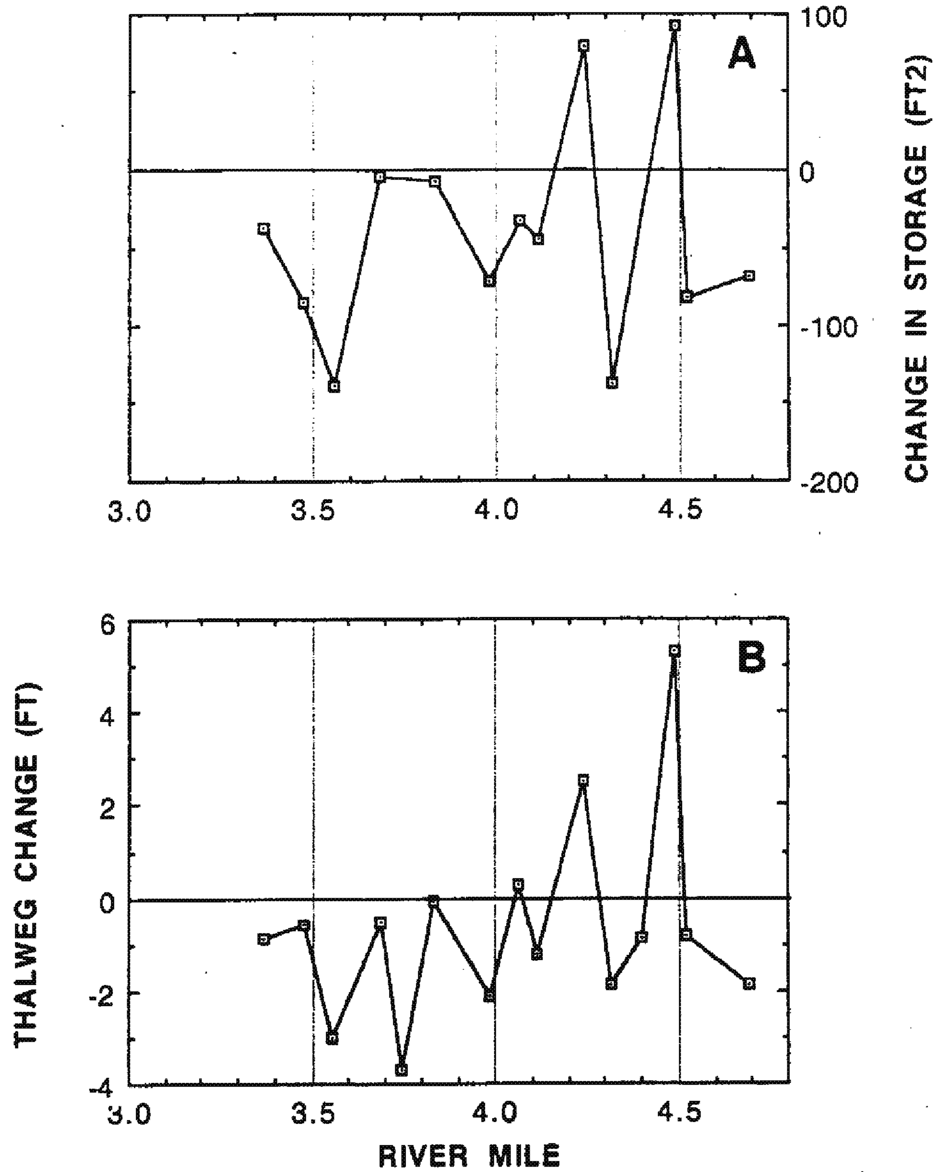

Figure 6-2. (A) Change in channel sediment storage, 1977-1993, at 13 locations between RM 3.3 and RM 4.8. (B) Change in channel thalweg, 1977-1993, at 15 locations between RM 3.3 and RM 4.8.

The 13 cross sections show a total loss of -11,600 yd^3 over a 1.3-mile-long reach over the 15-year period, or -600/yd^3/mi/yr. This trend of overall scour is also reflected by the changes in 15 thalweg elevations *(Figure 6-2B)*; 12 of the 15 changes are negative.

This result is somewhat surprising, because while only the upper few tenths of a mile of the reach has a declining gradient, and so overall the reach is not expected to aggrade significantly, there are some coarse sediment sources in the reach, and it is not expected to lose bed material. One possible explanation for the scour is that banks at most bends in the reach are riprapped ***(see Figure 10-1, map 1)***, including seven of the cross sections. Buer and others ***(1989)*** reported that the middle Sacramento River (California) was six feet deeper and 90 feet narrower at riprapped compared to eroding banks. This presumably would have happened in part because the river erodes its bed instead of the bank at the outside of a riprapped bend, and continues to deposit on the inside of the bend.

The cross sections in the study reach which showed net sediment loss did show a narrowing and deepening, but as indicated in Chapter 4 it is unclear how to interpret the Sacramento River study, and in any case there is not enough information from this reach of the Deschutes River to interpret a connection between riprap and channel morphology. To satisfactorily interpret the RM 3.3-4.8 reach, it would be necessary to resurvey more cross sections upstream and downstream of it. Also, in order to determine what if any effect riprap has on channel morphology in general, it would be necessary to resurvey more cross sections along the river, selected to assess the question of riprap's possible channel morphology effects.

6.3 Other Reaches

Table 6-1 indicates that a total of 10 river miles might be expected to experience some amount of aggradation. Most of the reaches are upstream of RM 30, where the gradient declines most rapidly. The 1977-1993 cross section comparison in RM 31.1-33.7 confirmed the prediction of Table 6-1.

Thalweg data was also found in two additional reaches. Longitudinal profiles were found for the river in RM 25.0-26.6 from 1970

(ACOE, 1970), and RM 11.9-13.8 from 1971 *(ACOE, 1972)*. Both were compared to the 1977 study thalwegs, but the comparisons are not reliable. because the quality of the older surveys is unknown. and because the intervals of the comparisons (1970 to 1977 and 1971 to 1977) are short. While there may be other data sources not found in conducting this study, it is not likely that any other sources are as extensive as the 1977 data which included 343 cross sections, and resurvey of more of the 1977 cross sections is probably the most reliable approach to determining the presence and rate of aggradation. Table 6-1 is one tool that could be used to focus efforts in areas most likely to be aggrading.

There is not now enough information on channel aggradation to reliably quantify aggradation for the entire study reach. However, extrapolation of rates from the upstream-surveyed reach can give an idea of a maximum aggradation rate, because the upstream reach probably has a high rate relative to other reaches owing to its location relative to sediment sources. Applying the RM 31.1-RM 33.7 rate to the 10 RM thought to have a potential to aggrade indicates a maximum of about 1,000-7,000 yd^3/yr in 1977-1993, depending on how the field results are interpreted. This is similar to bedload estimated from bank erosion of 7,000 yd^3/yr. Not all of this is expected to deposit, and some is expected to be lost to attritition, so that the 7,000 yd^3/yr forms an expected upper limit to, and almost certainly an overestimate of aggradation.

6.4 Chapter Summary

The estimated rate of bedload aggradation between 1977 and 1993 in the Deschutes River in RM 2-41 is 1,000 to 7,000 yd^3/yr, with the lower end of this range being a more likely estimate than the upper end. This aggradation is most likely to be concentrated in a total of about 10 river miles identified based on their gradient, channel confinement, and coarse sediment supply. Most are upstream of RM 30, where the gradient undergoes a substantial downstream reduction, and there are a number of coarse sediment sources and unconfined reaches. Resurvey of 1977 cross sections proved useful for measuring aggradation in two sample reaches, and is the most promising approach to better defining where and by how much the Deschutes River may be aggrading. It could also provide a base line for assessments of future bed material accumulation.

Resurvey of 1977 cross sections indicated net gain of bed sediment in RM 31.1-RM 33.7, which was expected based on the ranking of reach aggradation potential. Resurvey of 1977 cross sections in RM 3.3-4.8 showed net loss of bed material. The reach is not expected to have accumulated sediment, but the sediment loss is surprising. It is possible that an apparent narrowing and deepening resulted from riprap in the reach, but nothing can be concluded about this possible connection without more study. Resurvey of more 1977 cross sections in the Deschutes is needed both to adequately interpret the RM 3.3-4.8 reach, and to determine what if any effects riprap may have on channel morphology.

7.0 APPLICATION TO RIVER AND WATERSHED MANAGEMENT PLANNING

7.1 Overview

As indicated in the first chapter, the project of which this study is a part is motivated by overall objectives which include reducing loss of land to bank erosion, reducing aggradation-caused flooding, reducing sedimentation in Capitol Lake, and improving aquatic habitat. The purpose of this chapter is to apply the conclusions of this study toward the goal of an integrated plan that addresses these objectives.

This chapter is organized by these broad objectives. In each case, the following discussion applies this study's results toward refining objectives, identifying the most relevant strategies for meeting those objectives, and identifying additional information needed to refine objectives, resolve conflicts between them, further evaluate strategies, and to develop detailed plans.

7.2 Aggradation and Flooding

This study provides an indication of recent aggradation rates in two reaches, indicates reaches where aggradation may be occurring, and estimates the possible overall aggradation rate in the study reach. More information is needed to refine this objective, both on the rates and locations of aggradation, and also on the role aggradation may play in flooding. The following is a general outline of how to develop that information:

<u>Locations and Rates of Aggradation.</u> One approach to determining this is to survey 1977 channel cross sections, as was done in two reaches for this study, in additional reaches beginning with those identified in Table 6-1 as most susceptible to aggradation and where flooding is an identified problem. While resurvey of these older cross sections is approximate for the reasons given in Chapter 6.1, it can be done relatively inexpensively, it provides the best-available information on recent channel elevation changes, and the resurveyed cross sections can be the basis for future monitoring, which can be more exact. A second approach, or an additional approach that can be combined with the first is to map sediment stor-

age changes using a combination of aerial photos and field measurements of bars *(e.g. Madej 1992).*

Flood Height Objectives. In those reaches where flooding is identified as a problem and this study or results of additional cross section measurements indicates there is aggradation, flood height objectives need to be evaluated in a planning process. Most comprehensively, flood height objectives would be set by considering the ecological, geomorphic, and flood-water storage functions of overbank flooding, as well as property considerations.

Modelling of Aggradation Effects on Flooding. Standard engineering hydraulic modelling, of the sort used in the original FEMA study *(FEMA 1982, 1984)*, would determine what effect channel aggradation may be having on floods, or how future aggradation scenarios could potentially affect flooding. Cross sections are a necessary basis for such modelling, and could include resurvey of the 1977 cross sections supplemented with new cross sections in some reaches where channel hydraulics have changed or where more detailed modelling is appropriate than in the original FEMA study.

Evaluation of Potential Strategies. If aggradation is determined to be having an effect on flood heights, and those heights vary from objectives set in a planning process, the appropriateness and efficacy of sediment removal, land-use zoning, and sediment source reduction would need to be evaluated as potential strategies. Hydraulic modelling can be used to evaluate whether channel-sediment removal would effect the relevant change in flood heights. General information on determining whether removal can be done without causing ecological and geomorphic problems can be found in a report by Collins *(1994)*.

This study includes most of the information needed for identifying important sediment sources in or upstream of an aggrading reach, and for evaluating the economic and physical feasibility of source reduction. The issue of fitting bank protection projects into a comprehensive approach that considers all objectives will be discussed below. Finally, the appropriateness of a land-use zoning approach to flood-hazard management could be evaluated in a planning context.

Installation of Monitoring Program. Cross sections can also provide an ongoing monitoring network maintained at low cost, for the purpose of periodically assessing aggradation rates, as well as for determining the efficacy and ecological consequences of sediment source reduction or gravel removal efforts.

Resolution of Questions about Land-use Effects on Flooding. Finally, while there is not at this time strong evidence for suspecting a land-use effect on flooding, an improved watershed runoff assessment will help to resolve the issue. Techniques and available data for assessing the land-use effects on floods in forested headwaters, while still limited, have both improved since earlier assessments were made in the Deschutes River basin.

7.3 Protection and Restoration of Aquatic Habitat

Detailed planning for aquatic habitat needs to be based on a comprehensive survey of historic and existing conditions and an analysis of critical habitat factors. While some initial surveys have been conducted primarily in tributaries within the forested headwaters ***(Schuett-Hames and others 1991)***, a comprehensive aquatic habitat evaluation is not yet available. A comprehensive analysis would identify the relative importance of protecting or restoring various habitat elements in particular reaches, such as woody debris, off-channel habitat, shading, or pools, and their relative importance within a basin-wide context.

In the absence of a comprehensive habitat survey, this discussion is limited to identifying ways in which strategies for realizing other obectives, such as bank protection projects, may potentially conflict with the quality or quantity of aquatic habitat, and also to general opportunities for improving aquatic habitat.

Evaluation of Conflicts with Mechanical Bank Protection. The strategy of using bank protection to slow bank erosion to reduce loss of land and sediment loads is potentially in conflict with the objective of protecting and improving aquatic habitat. This needs to be specifically evaluated in the Deschutes River. The following issues are among those relevant to such an evaluation.

(a) *Effects of riprap bank protection on local and downstream channel morphology and on fish habitat.* As mentioned previously, bank protection could cause changes to the channel's cross-sectional shape, although this issue awaits study. In addition, in some reaches it may be possible to starve downstream areas of bedload, potentially causing downstream bed armoring and possibly scour. There has been some study of the short-term effects of installing bank protection on habitat use ***(Knudson and Dilley 1987)***, but no studies of long-term effects on channel form and habitat.

In addition, this study found that locations of many erosion sites are ephemeral. Because of this, and the tendency for bank protection to cause channel adjustments, bank protection in one area can lead to the need for application upstream and downstream of that area, or the need for "progressive" armoring.

Some information is provided by this study for evaluating these issues in more detail, and needed additional information could be developed with a modest level of effort. Existing information on locations and rates of erosion along the river, combined with a field assessment of the bedload supply relative to transport in a particular reach ***(for example the method of Dietrich and others 1989, discussed in Washington Forest Practices Board 1993)*** can be used to assess the potential for particular bank protection projects to critically limit the downstream supply of spawning gravel in that reach.

Additional information needed to evaluate the effects of riprap on local channel morphology could be gained by a field study that would include resurveying additional 1977 channel cross sections at bends with and without riprap, in combination with a field assessment of physical aquatic habitat. A monitoring plan could also be implemented to examine future changes in channel form adjacent to recently-installed bank protection. Finally, the need for "progressive" armoring in a particular reach can be evaluated by assessing the historic channel form in a particular reach, using channel mapping developed for this report in combination with the record of the persistence of erosion sites ***(Tables 4-3 and 10-2)***. along the river.

(b) *River-floodplain connection*. Mobile, alluvial rivers such as the Deschutes are connected with their floodplains through side channels and sloughs, which can provide important habitat, especially for juvenile coho salmon ***(Peterson and Reid 1984)***. Ponds created by beaver also provide important coho salmon habitat ***(Leidholt-Bruner and others 1992; Nickelson and others***

1992; Peterson 1982; Bryant 1984). River-floodplain connections can also play an important flood-reduction role by storing floodwaters that would otherwise aggravate downstream flooding. In addition, processes of riparian forest and wetland succession and habitat diversity depend on a river's lateral mobility *(e.g. Nanson and Beach 1977; Shankman 1993).*

Based on studies of other regional rivers, river-floodplain connection has already probably been reduced in the Deschutes River from historic conditions by ditching and draining of floodplains, channel clearing, and channelization *(Sedell and Luchessa 1982)*, and widespread beaver trapping *(Naiman and others 1988).* The resulting salmonid habitat losses in the lowland portions of regional rivers may have been quantitatively significant *(Beechie and others 1994).* Additional artificial bank protection can further reduce this connection and additionally, it can limit attempts to restore historic river-floodplain connections, some successful attempts at which have been made for juvenile coho salmon *(Cederholm and others 1988; Cederholm and Scarlett 1991).*

The location and importance of historic and existing off-channel habitat along the Deschutes River needs to be evaluated, as well as the potential for particular bank protection projects to prevent reconnection of lost habitat or to cause loss of existing off-channel habitat.

(c) *Wood recruitment.* Riprap bank protection can limit production of wood to the channel, which is important for aquatic habitat, by limiting the supply of streamside trees and also by limiting the river's lateral migration and bank undercutting. This issue needs to be evaluated, along with an assessment of the importance of wood production to the channel, in evaluating bank protection strategies, as well as the potential to use "bioengineering" approaches to bank stabilization.

<u>Comprehensive Riparian Restoration Planning</u>. Restoration of mature riparian forest can improve various aspects of aquatic habitat, including wood recruitment and shading. In addition, it can help meet other objecitves by limiting the transport of pollutants to the river and providing terrestrial habitat *(Johnson and Ryba 1992; O'Connell and others 1993)*, and by allowing continued lateral

river movement, conserve river-floodplain connection and function, and *maintain continued bedload recruitment.*

Among the steps needed to develop a detailed riparian forest management plan is to delineate a riparian management zone. As described earlier in this report ***(Chapter 4)***, sections of the river are easily erodible along agricultural land along which there is no riparian vegetation, and other areas could become so if a forest buffer is eroded landward into agricultural land. The probable future lateral migration in a particular reach needs to be considered in evaluating the landward distance which would be managed for producing mature trees, and included in land-use zoning or other means for determining riparian land uses.

Another step is to evaluate the potential to restore riparian forest. This report provides most of the information needed for evaluating eroding sites and reaches that could feasibly be made more stable by restoring mature riparian vegetation. For example, information has been presented on bank height, which indicates the relative efficacy of vegetation at bank stabilization; on the volume and persistence of erosion at sites; on existing riparian vegetation conditions; and on the geomorphic context in various reaches. Such an evaluation would indicate at which sites riparian forest restoration could be expected to slow erosion. Riparian vegetation *restoration has recently become a focus of management efforts in* headwater forests ***(FEMAT, 1993; USDA Forest Service 1993).*** Depending on the situation, vegetation management can include the thinning of dense, immature conifer stands, thinning of hardwoods and interplanting of conifers, and in areas now lacking any riparian vegetation, planting species that could rapidly stabilize the site, possibly in connection with various bioengineering approaches.

Sedimentation, Habitat, and Bank Erosion. Detailed aquatic habitat surveys may identify reaches in which fine or coarse sediment deposition is identified as a limiting factor. This report provides enough information to generally link these reaches with potential sediment sources, which is the first step in evaluating strategies for improving particular habitats.

7.3 Reducing Sedimentation to Capitol Lake

The objective for reducing sedimentation in Capitol Lake is to reduce the river's sediment inputs, especially suspended sediment. The following considerations are relevant to planning for this objective.

Assess Potential for Source Reduction. It is helpful to know how much overall reduction of watershed erosion could be achieved without prohibitive expense or ecological damage for the purpose of planning the extent to which source reduction or dredging will be needed to maintain the lake's capacity. Doing so will provide a rational basis for defining a quantitative target objective for source reduction. A common-sense, ecologically-conservative initial target for discussion purposes might be to reduce erosion levels to those naturally occurring without land-use impacts.

This hypothetical "natural" erosion rate is not defined. As indicated previously, the overall sediment load of the Deschutes River is comparable to that in similar, nearby basins ***(Chapter 4.5)***, although erosion in all of these basins has probably been increased by land use over erosion rates in their undisturbed condition. However, there is not at this time strong evidence that there has been a significant, systematic increase in the rate of bank erosion along the mainstem Deschutes River in the photographic record ***(Chapter 4.3)***. It is possible that such an increase may have occurred prior to the photographic record in response to riparian logging ***(Chapter 5.2)***, but this is unknown. It is reasonable to assume that some bank erosion can be reduced by riparian vegetation restoration, especially on lower banks that now have no vegetative protection, but this potential overall reduction may not be great.

The potential also exists to reduce erosion from the forested headwaters by reducing road- and logging-related erosion and landsliding and by restoring riparian vegetatation in tributaries. This potential was not assessed as part of this study, but could be as part of the state's Watershed Analysis proceedure or other process.

It is likely that effecting a substantial reduction in mainstem bank erosion below the hypothetical "natural" erosion rate would require widespread bank protection, because this would be required to stop erosion at many of the largest, and most of the highest banks.

Enough information was developed in this report to make a rough, initial assessment of possible erosion reductions that could be expected under different scenarios of bank protection.

Once a quantitative objective for source reduction as an approach to managing sedimentation in Capitol Lake is determined based on economic and ecological feasibility, sources can be ranked according to their overall importance, cost of stabilization, ecological costs, technical chances of success, and time frame of reduction measure.

7.5 Reducing Loss of Land to Bank Erosion

Several strategies are relevant to meeting this objective, including zoning, riparian vegetation restoration, and engineering approaches to bank stabilization. In the absence of evidence for a watershed-scale land-use cause for bank erosion, this appears to be a reach- and site-specific problem. The following additional information would facilitate planning at that scale.

There are several reasons why site-specific evaluations are needed. The first is that some approaches to bank stabilization will only be effective in some settings. For example, on low banks ***(Table 4-1)*** depending on the rate of erosion, vegetative stabilization may be feasible. On the highest banks, vegetation will not be effective at slowing lateral erosion, because terraces erode as a result of undercutting well below the rooting zone of trees atop the terrace, and artificial bank protection or land-use zoning are appropriate strategies to evaluate in context of protecting aquatic habitat and riverine function.

The second reason is that this study measured bank erosion remotely from aerial photos, and these rates are approximate. This may be especially true on higher banks, where there is opportunity for greater measurement error than on lower banks, which are better defined on aerial photos. In many cases where loss of property is an issue, erosion rates will have been carefully observed by landowners and others, and these obserfations may be more reliable than those estimated in this study. A combination of local rate observations, the rates determined in this study, and an assessment of past and likely future changes in channel plan form will allow an assessment of possible future erosion rates at individual sites.

Finally, at a small number of eroding, high terraces, the potential exists for land uses to affect the recharge of groundwater, which could affect the terrace slope stability. This issue was not addressed within this study, and would need to be evaluated on a site-by-by site basis.

8.0 CONCLUSION

The dominant causes of channel erosion along the Deschutes River are geologic and topographic. The river since deglaciation about 12,000 yr ago has cut a valley into glacial outwash silts, sands, and gravels, forming terraces which the river undercuts at the valley sides as it continues to widen its valley in this process of post-glacial landscape evolution. These easily-erodible terraces are the primary source of sediment in the watershed. Bank erosion is also induced because the river undergoes a reduction of gradient as it emerges from its headwaters, especially in the first seven or eight miles downstream of Deschutes Falls, and this causes gravel bars to deposit and the river to migrate laterally.

Bank erosion is integral to riverine landscape and ecosystem function, being the primary source of spawning gravel and wood recruitment. Lateral channel mobility also creates and maintains off-channel aquatic habitat which can be critical to some salmonid species. The extent of natural landscape and ecosystem function remaining along the Deschutes River is unusual among regional rivers. It represents an important resource to protect and restore.

These two facts--the natural occurrence of bank erosion in the Deschutes River and its ecological importance--point to the need to carefully focus objectives for reducing bank erosion. This study's goal was to lay the groundwork for a program to reduce bank erosion in order to reduce the overall sediment load of the river, reduce the loss of land to bank erosion, slow the rate of sedimentation in Capitol Lake, and mitigate the build up of bedload which could aggravate flooding. A detailed plan to bring about a general reduction cannot be designed in an informed manner until a reduction target is set that takes into account the natural function of bank erosion. An ecologically conservative target might be to restore rates and patterns of erosion to that which would occur "naturally" or in the absence of land use effects.

While land uses have probably increased the rate and distribution of bank erosion somewhat over natural, there are no obvious "smoking guns." The erosion rate of the Deschutes River basin is not larger than comparable rivers. Nor is there compelling evidence that bank erosion rates have increased systematically in the last 50 years, which is the period of aerial photographic record for the Deschutes River. While landsliding from logging and road building in *the river's headwaters have significantly affected channel* conditions in tributaries, this landsliding has not produced enough coarse sediment to the mainstem to have noticeably increased the rate of mainstem bank erosion. Nor do timber harvest or roads appear from available data to have affected the size of floods, although current understanding of the potential effects of these forestry activities on floods in the Deschutes River is imperfect and bears further analysis.

Still, land use, especially along the mainstem, has probably increased bank erosion to some, albeit poorly-quantified, extent. Agricultural lands having no riparian vegetation are disproportionately common sites of eroding banks, and more erosion sites could develop with time in locations where the river could migrate into agricultural lands now protected by a narrow forest buffer. It may be possible to reduce erosion from and slow the loss of these agricultural lands by restoring mature riparian forests to them, although probably only on shorter banks where mature tree roots can effectively resist erosion. Opportunities may also exist to slow bank erosion along presently forested shorter banks by promoting the development of mature trees, the cutting of which may have destabilized the channel prior to the photographic record, although this is speculative. It is also possible that land uses may affect the groundwater and slope stability of some high terraces, but this was not evaluated. Finally, while landsliding in headwater tributaries from forestry activities has not alone noticeably increased mainstem bank erosion, it may have contributed to local mainstem bank erosion near tributary confluences, and it is possible to reduce future headwater landslide contributions to the mainstem.

While mainstem bank erosion is the river's primary source of both fine and coarse sediment, opportunities also exist for reducing land-use sources of the river's suspended sediment load by reducing erosion in the forested headwaters. Sediment from the headwaters probably accounts for about one-fifth of the river's total load of suspended sediment, based on the limited information available. Forest harvest and roads have in the last several decades caused a significant amount of this erosion. The state's Watershed Analysis process is an appropriate forum for continuing to reduce erosion by improving headwaters forest practices.

However, it is important to keep in mind that land-use effects do not appear to be as important as geologic and topographic conditions in causing mainstem bank erosion. Thus it is also important to focus objectives in order to define the full range of possible strategies beyond that of effecting a substantial reduction in mainstem bank erosion, because such a reduction is probably only possible by a program of widespread bank protection, which is the *only effective means to stop erosion* of high terraces of non-cohesive sediments, which constitute the primary sediment source. Such a program could be prohibitively expensive and also cause unwanted changes to the river and its ecology.

This study provides more focus to the objective of reducing the role of bed aggradation on flood hazard, but more information is needed. This study provides a rough prediction of the possible overall rate of aggradation and indicates in which reaches it is more likely to occur than others. The study also found that resurveying cross sections from a 1977 flood study is a promising approach to assessing recent trends in bed elevation. However, in order to proceed in the planning process, it is necessary to gather more information on where and by how much the river bed may be aggrading, and to what extent this might affect flooding. If it then appears that aggradation in some reaches is increasing the flood hazard, the issue could be approached as a reach-scale problem using a range of approaches including zoning, sediment removal, and possibly source reduction. Bringing this objective into better focus with more information is essential if the issue is to be tackled in an effective, economical, and ecologically sound way.

Another overall planning objectives is to slow the rate at which Capitol Lake is filling with sediment. As indicated above, there are opportunities to reduce land-use caused sediment sources. These include reducing headwater forestry-related erosion, and improving mainstem riparian land uses. However, the amount of these potential reductions is almost certainly less than the watershed's natural erosion rate, and because of its shallowness, Capitol Lake would still fill fairly rapidly even in the absence of land-use related erosion. Substantially reducing mainstem bank erosion to a level less than the "natural" rate is probably only possible using widespread bank engineering projects, because high, non-cohesive terraces are the primary eroding sites and engineering measures are the only way to effectively stop erosion from most of these sites. Besides the expense of such an effort, it also has the potential to effect widespread change to the river's geomorphic and ecological character. While contemporary thinking in watershed management emphasizes the need to solve downstream sedimentation problems by reducing watershed erosion, this may not fully apply to the problem posed by Capitol Lake, which is a shallow, artificially created lake in which any amount of sediment inflow causes a noticeable loss of capacity, and the effort to substantially reduce sediment inflow would involve undertaking an expensive and ecologically troublesome battle with a natural erosion process. While it is worth reducing land-use sources of erosion as a means to reducing sedimentation to the lake (and for meeting other objectives such as improving aquatic habitat by improving riparian conditions), it may be more sound for the watershed's overall habitat to emphasize dredging rather than a widespread program of bank protection, and the tradeoffs between the two need to be evaluated.

This study provides some of the information needed to devise an approach to reducing the loss of land from bank erosion, another overall planning objective. Maps of historic channel position (developed for this study but not included in this report) provide the basis for zoning according to likelihood of channel migration. Information on the geometric characteristics of eroding banks and of riparian vegetation conditions provide the basis for determining feasible bank erosion control measures. Lacking is information on how the locations or relative amounts of bank-erosion-control might affect the river channel morphology or aquatic habitat. This information needs to be developed in connection with a determination in a planning context of to what extent and where zoning versus bank protection will be employed as a strategy.

There is a lack of detailed information from the Deschutes River on the existing and historic aquatic habitat and its interaction with river-channel geomorphology, and this information is essential in several respects. It is needed to assess how specific bank protection projects could change river geomorphology and habitat. in addition, improving aquatic habitat was a major application of this study. It is not possible to apply this study to that goal without more information on the location, condition, and importance of specific habitats.

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10.0 DATA APPENDICES

Figure	10.1	Maps of eroding banks
Table	10.2	1941-1991 photo-measured bank erosion
Table	10.3	1981-1991 bank-erosion calculations
Table	10.4	1972-1981 bank-erosion calculations
Table	10.5	1993 field observations at eroding banks
Table	10.6	1941-1991 riparian vegetation inventory
Table	10.7	1993 cross-section data
Table	10.8	Landslide data

Figure A-1: Erosion Site Location Maps

Base map is 1:12,000-scale Washington Department of Natural Resources Orthophoto maps, from 1991 aerial photos. Maps show:

(1) Boundaries of segments used by McNicholas *(1984)* and in this study (renumbered from the 1984 report). River miles of segment boundaries are given in Table 2-1;

(2) Bank protection, from 1993 field survey between RM 2 and RM 16 and between RM 31 and 40; the reach between RM 16 and RM 31 was not field surveyed, and the maps do not show bank protection that may be present in this reach;

(3) Location of erosion sites. Included are sites (1) identified by McNicholas *(1984)* (site numbers end in multiples of 10); (2) identified by comparison of 1981 and 1991 aerial photos; or (3) observed in 1993 field survey between RM 2 and RM 16 and between RM 31 and RM 41.

EXPLANATION: (1) McNicholas *(1984)* study site; (2) 1981-1991 photo site; (3) 1993 field site; (A, PA, S) 1993 field status: Active, Partially Active, Stable

Site Number			Site Number	
100	1, 2		414	3 (PA)
105	2		415	3 (PA)
110	1, 2, 3 (A)		420	1, 3 (PA)
117	2, 3 (PA)		430	1, 2, 3 (PA)
120	1, 2, 3 (S)		435	2, 3 (A)
130	1, 2, 3 (PA)		440	1, 2, 3 (A)
135	2, 3 (PA)		450	1, 3 (PA)
140	1, 2, 3 (S)		460	1, 2, 3 (PA)
150	1, 3 (PA)		470	1, 3 (S)
160	1, 2, 3 (PA)		480	1, 2, 3 (S)
170	1, 2, 3 (PA)		490	1, 3 (S)
171	2, 3 (PA)		500	1, 2, 3 (PA)
171.5	2		510	1, 3 (PA)
172	2, 3 (PA)		520	1, 2, 3 (PA)
173	2		530	1, 3 (S)
180	1, 2, 3 (A)		535	2, 3 (PA)
190	1, 2, 3 (PA)		540	1, 2, 3 (PA)
200	1, 2, 3 (A)		548	3 (PA)
210	1, 2, 3 (A)		550	1, 3 (S)
220	1, 2, 3 (PA)		560	1, 3 (A)
230	1, 2, 3 (PA)		565	2, 3 (A)
235	2		570	1, 3 (S)
240	1, 2, 3 (PA)		580	1, 3 (A)
250	1, 3 (PA)		590	1, 2, 3 (A)
260	1, 2, 3 (PA)		592	3 (A)
270	1, 2, 3 (S)		595	2, 3 (PA)
280	1, 2, 3 (PA)		597	3 (PA)
285	2, 3 (PA)		600	1, 3 (PA)
288	3 (PA)		602	2, 3 (A)
290	1, 3 (S)		605	2, 3 (PA)
300	1, 3 (S)		610	1, 2, 3 (S)
310	1, 3 (S)		620	1, 2, 3 (PA)
320	1, 3 (S)		625	2, 3 (A)
330	1, 2, 3 (S)		630	1, 2, 3 (A)
340	1, 3 (PA)		640	1, 2, 3 (S)
350	1, 2, 3 (S)		650	1, 2, 3 (PA)
360	1, 2, 3 (A)		660	1, 3 (S)
361	2, 3 (PA)		670	1, 2, 3 (S)
370	1, 2, 3 (PA)		680	1, 2, 3 (PA)
380	1, 2, 3 (PA)		690	1, 2, 3 (PA)
390	1, 3 (S)		700	1, 2, 3 (PA)
400	1, 3 (S)		710	1, 2, 3 (A)
410	1, 2, 3 (PA)		720	1, 3 (A)

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730	1, 2, 3 (S)		1083	2, 3 (PA)
740	1, 2		1085	3 (PA)
750	1, 2		1090	1, 2, 3 (A)
760	1, 2		1095	2
770	1, 2		1100	1, 2, 3 (S)
772	2		1110	1, 3 (PA)
780	1, 2		1120	1, 2, 3 (S)
790	1, 2		1130	1, 2, 3 (PA)
800	1, 2		1135	3 (PA)
810	1		1140	1, 3 (S)
815	2		1145	3 (A)
818	2		1150	1, 2, 3 (A)
820	1, 2		1160	1, 2, 3 (A)
828	1, 2		1170	1, 2, 3 (S)
830	1, 2		1180	1, 3 (A)
838	2		1190	1, 2, 3 (A)
840	1, 2		1200	1, 3 (PA)
850	1		1210	1, 2, 3 (A)
860	1, 2		1220	1, 2, 3 (A)
870	1		1230	1, 2, 3 (PA)
880	1, 2		1235	3 (A)
888	2		1240	1, 2, 3 (PA)
890	1, 2		1250	1, 2, 3 (A)
895	2		1260	1, 3 (A)
896	2		1270	1, 2, 3 (PA)
897	2		1275	1, 2, 3 (A)
900	1		1279	2, 3 (PA)
910	1, 2		1280	1, 2, 3 (PA)
920	1		1290	1, 2, 3 (S)
930	1, 2		1300	1, 2
940	1		1310	1, 2, 3 (A)
950	1, 2		1320	1, 2, 3 (A)
960	1, 2		1330	1, 2, 3 (A)
970	1		1340	1, 2, 3 (A)
980	1, 2		1350	1, 2, 3 (PA)
990	1, 2		1360	1, 3 (PA)
1000	1		1370	1, 3 (S)
1001	2		1380	1
1010	1		1390	1, 3 (A)
1011	2		1400	1, 3 (A)
1015	2		1410	1, 3 (A)
1020	1, 2		1420	1, 3 (A)
1025	2		1430	1, 2, 3 (A)
1030	1, 2, 3 (A)		1440	1, 2, 3 (A)
1040	1, 2, 3 (PA)		1442	2
1050	1, 3 (PA)		1450	1, 2, 3 (A)
1060	1, 3 (S)		1460	1, 3 (A)
1068	2		1470	1, 3 (PA)
1070	1, 2, 3 (PA)		1472	3 (PA)
1080	1, 2, 3 (PA)		1480	1, 3 (PA)
1082	2, 3 (PA)		1485	3 (PA)

Appendix 1

SCALE 1 : 12 000

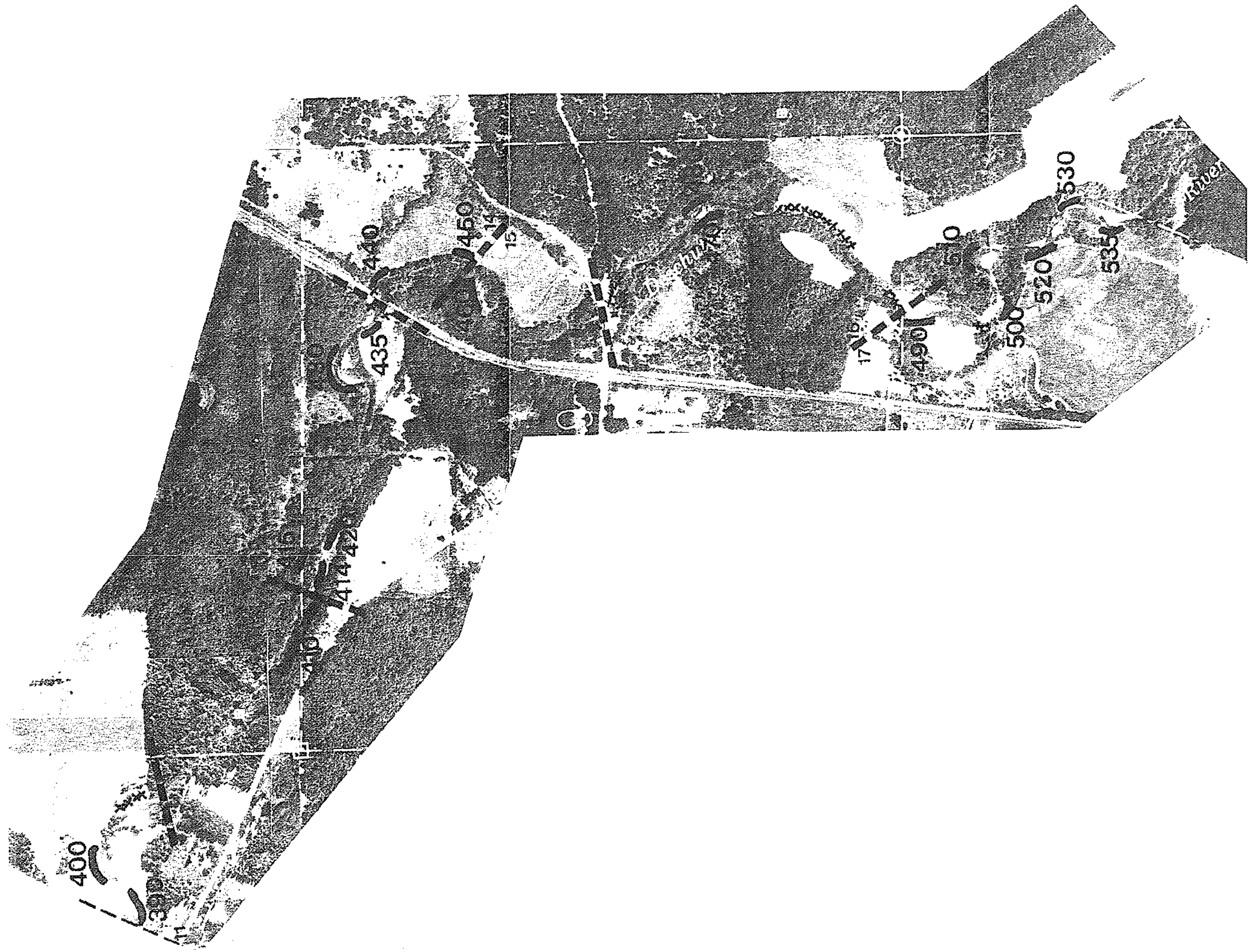
2000 Feet 1000 0 ¼ ½ ¾ 1 Mile

MAP 1

SCALE 1:12000

2000 Feet 1000 0 1/4 1/2 3/4 1 Mile

MAP 2



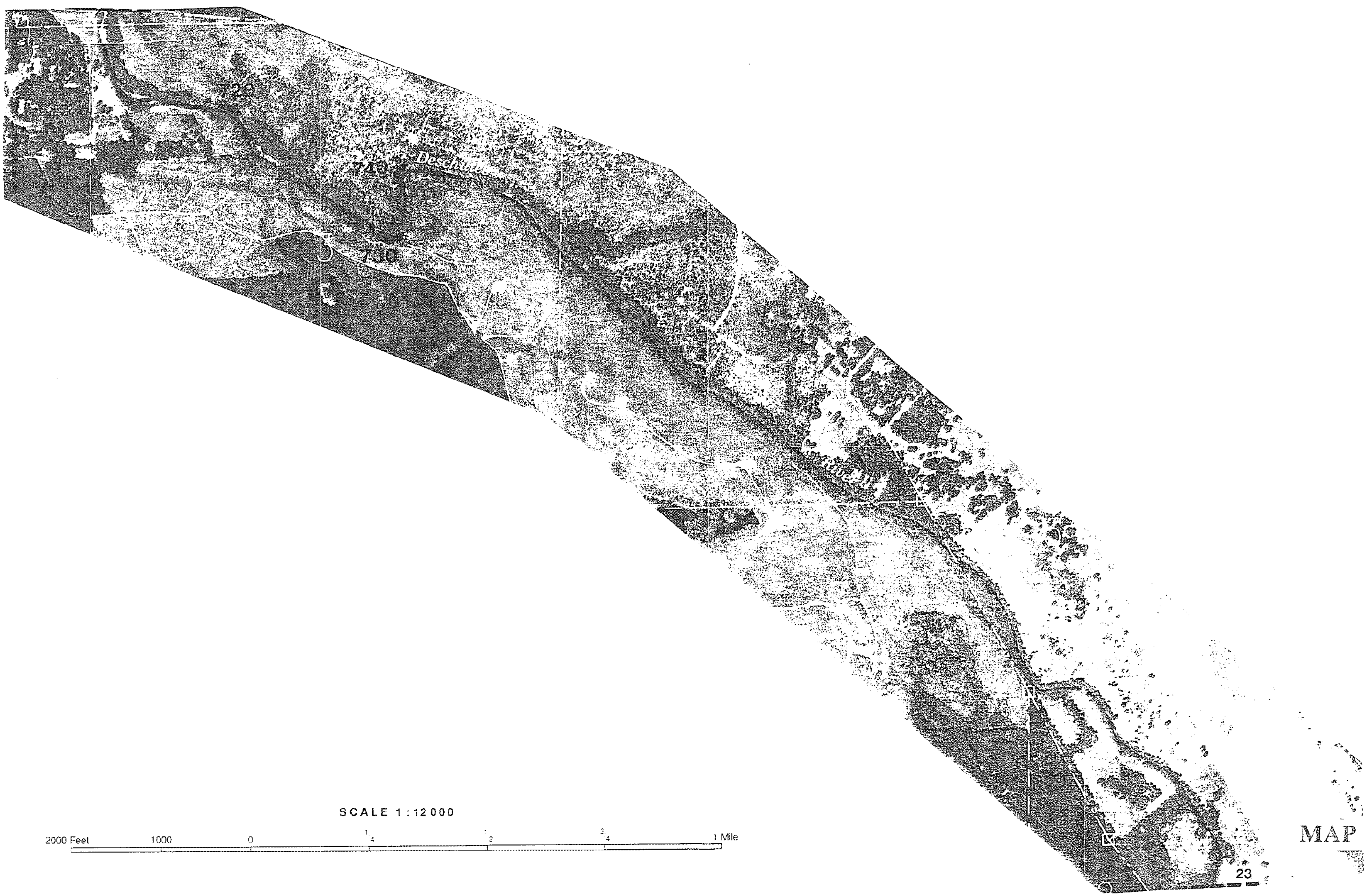
SCALE 1:12000

2000 Feet 1000 0 1/4 1/2 3/4 1 Mile

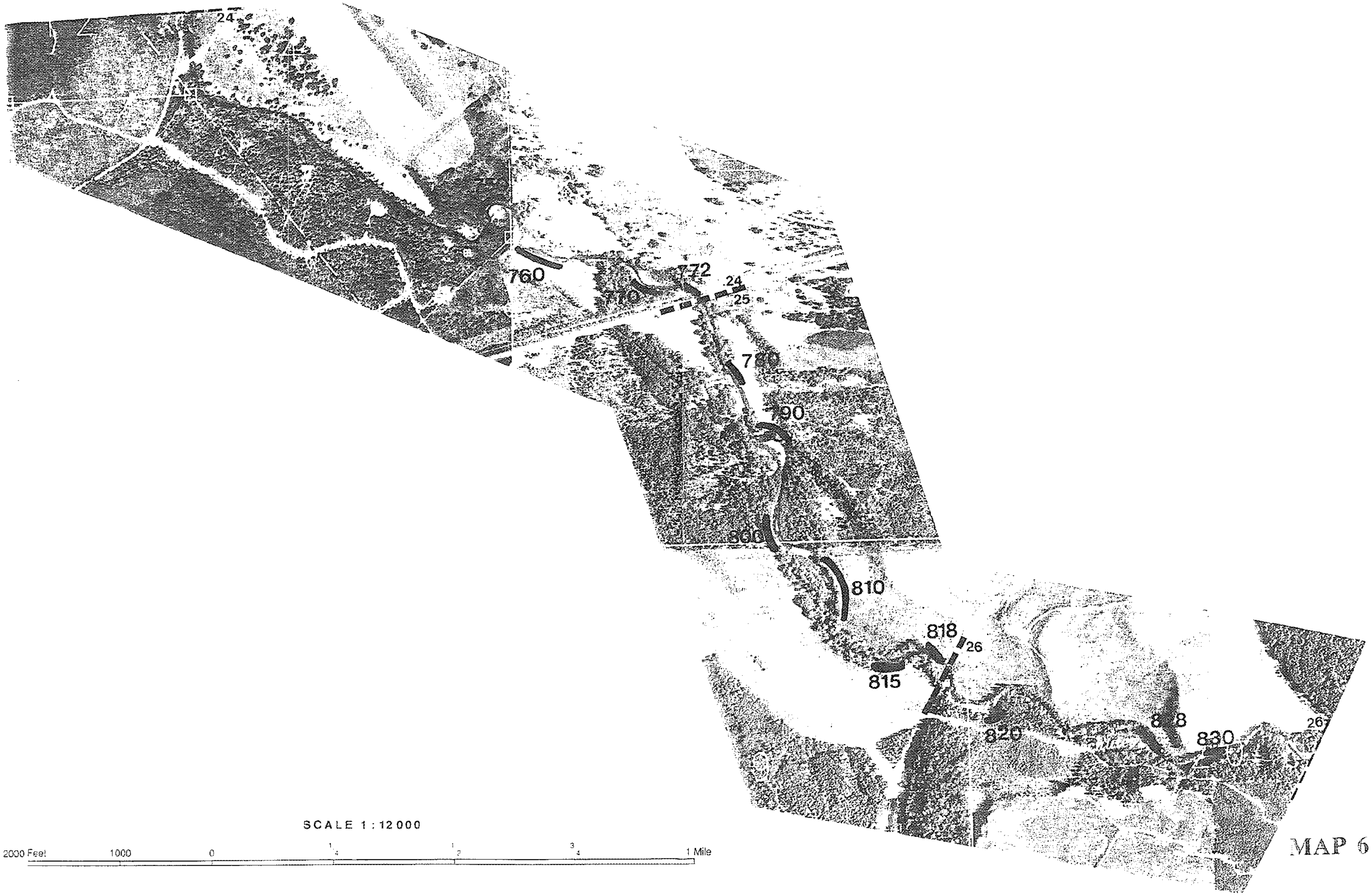
MAP 3


590
580
595
600
19
20
605
620
548
570
540
17
18
550
565
560
625
630
640
650
21
22
670
680
690
700
710
SCALE 1:12000
2000 Feet
1000
0
1 Mile

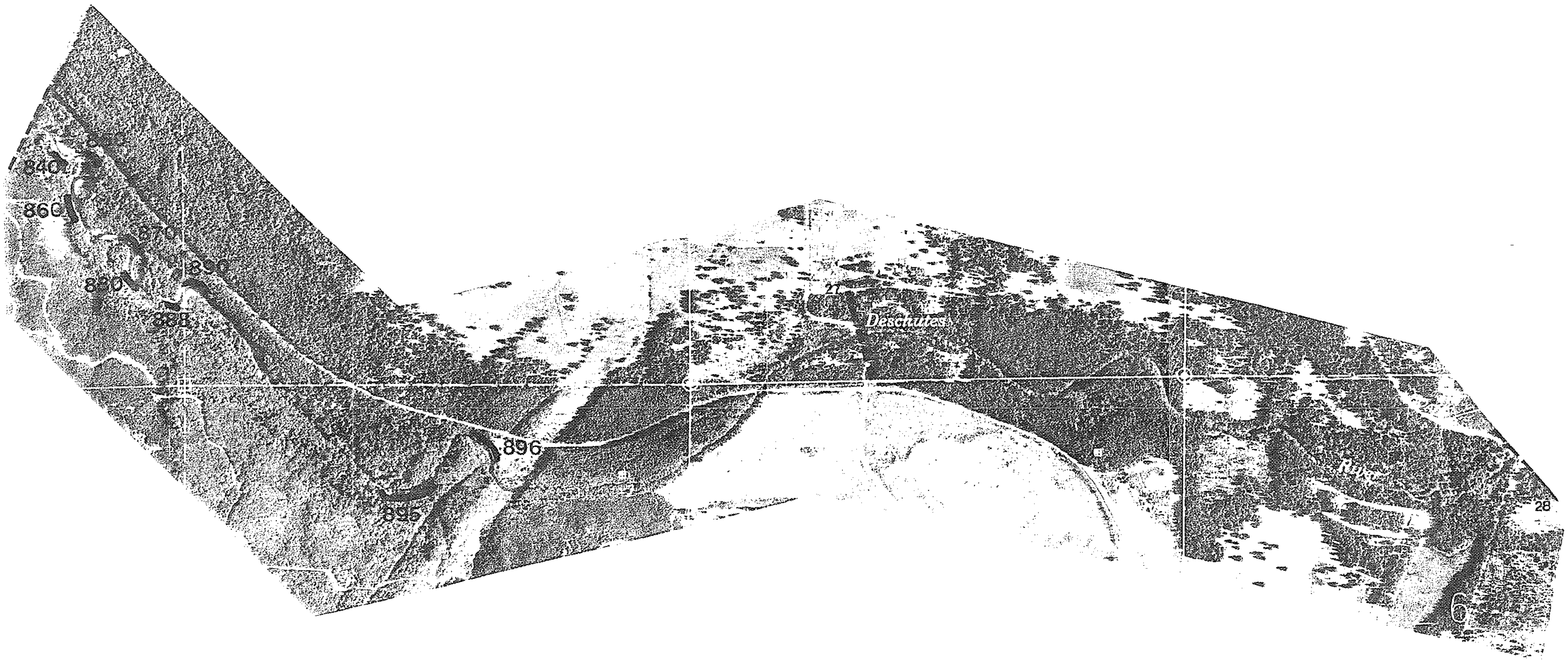
MAP 4


720
740
Desch
750
River
23
SCALE 1:12000
2000 Feet
1000
0
1/4
1/2
3/4
1 Mile

MAP 5


24
760
770
772
24
25
780
790
800
810
818
26
815
820
830
26
SCALE 1 : 12000
2000 Feet
1000
0
1/4
1/2
3/4
1 Mile

MAP 6



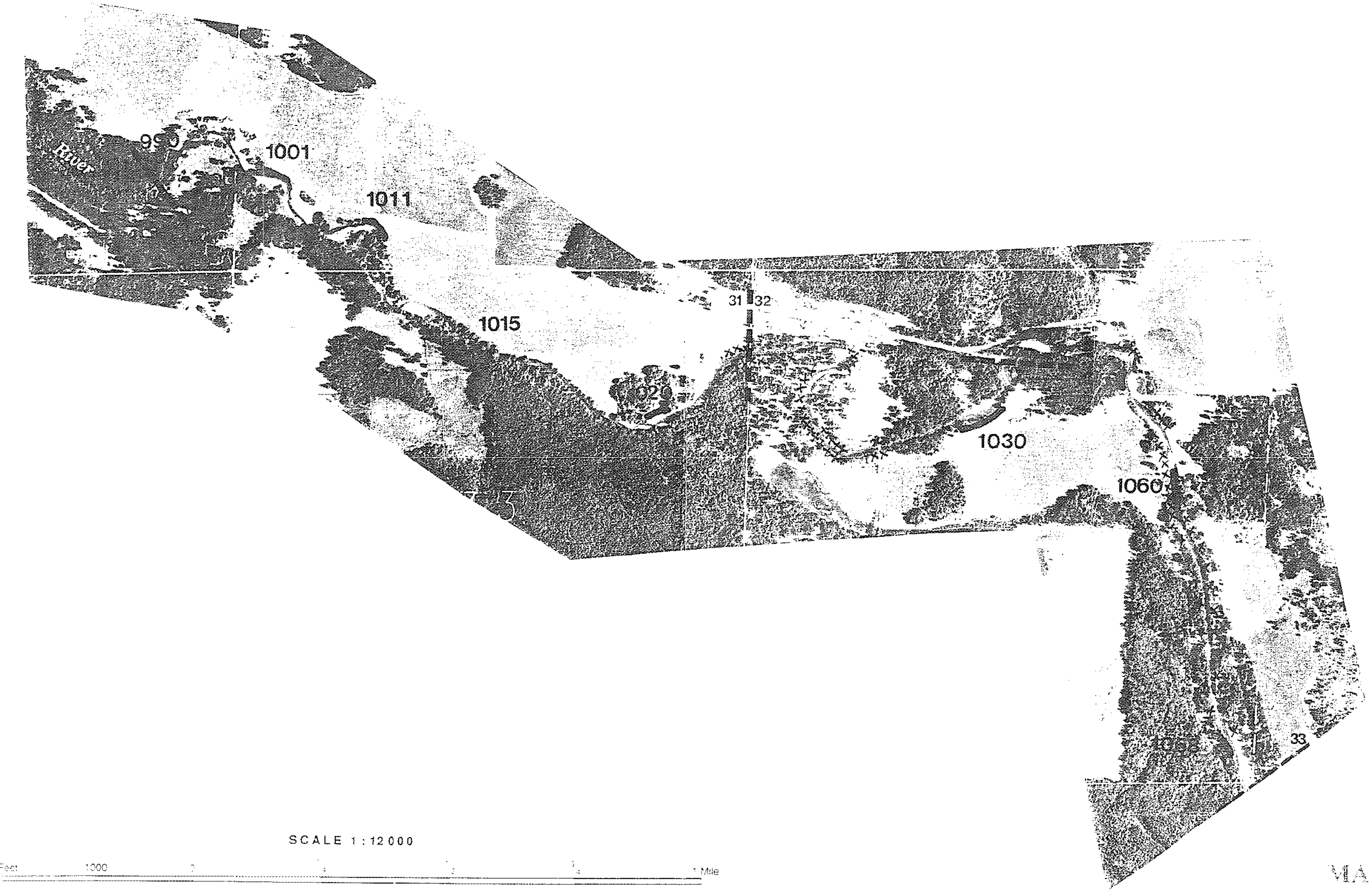
SCALE 1 : 12000

2000 Feet 1000 0 1/2 1 Mile

MAP 7


897
900
910
920
930
940
950
960
970
29
30
SCALE 1:12000
2000 Feet
1000
0
1 Mile

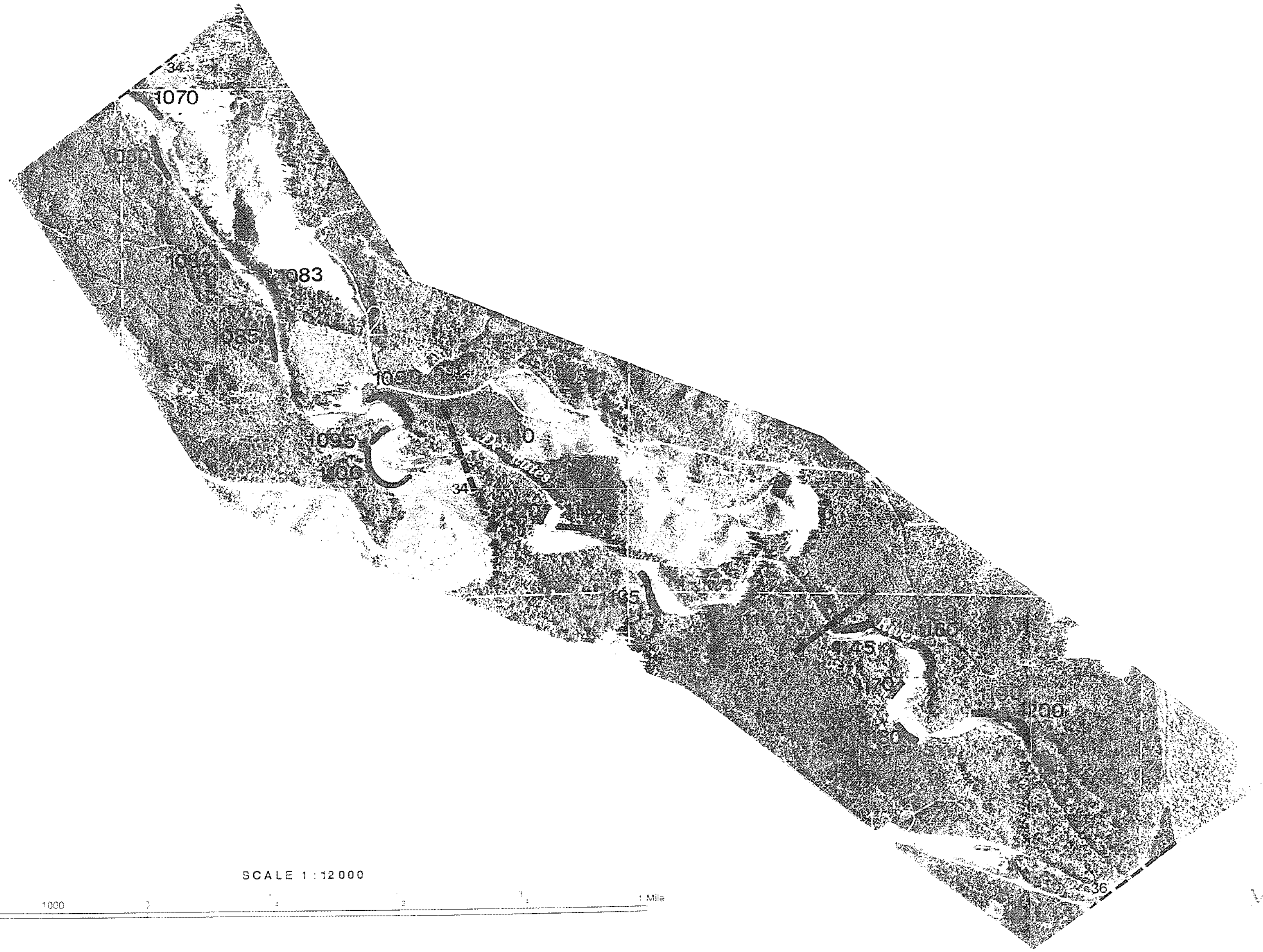
MAP 8



SCALE 1 : 12 000

2000 Feet 1000 1 Mile

MAP 9



SCALE 1:12000

2000 Feet 1000 1 Mile

MAP 10

SCALE 1:12000

2000 Feet 1000 0 1 Mile

MAP 11

Table A-2: *1941-1991 Photo-measured Bank Erosion Data*

Column A: Erosion site number. Numbering system based on that used by McNicholas *(1984)*. Sites identified in 1972-1981 field study from 1981-1991 photo comparison, and 1993 field survey are located on maps, Figure A-1. Older sites are at locations intermediate to these.

Column B: Segments are same as those used by McNicholas *(1984)*, renumbered for this report. See Table 3-1 for river miles of segment boundaries.

Columns C-H: Riparian codes are given in Table A-6. Where more than one code is given for a photo year (seperated by slash marks), the first is closest to the river.

Columns J-W: Time periods are those bracketed by aerial photos. Width (ft) is lateral bank erosion during time period, averaged over the length (ft) of eroding bank, as identified on the photos. Area (ft^2) is the product of the average width and length in the preceding columns.

1941-1991 BANK EROSION DATA

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	Erosion	Seg			Riparian Condition					1941-1953			1953-1964			1964-1972			1972-1981			1981-1991	
2	Site	ment	1941	1953	1965	1972	1981	1991	Width	Length	Area	Width	Length	Area	Width	Length	Area	Width	Length	Area	Width	Length	Area
3									(ft)	(ft)	(ft2)	(ft)	(ft)	(ft2)	(ft)	(ft)	(ft2)	(ft)	(ft)	(ft2)	(ft)	(ft)	(ft2)
4	99	1	B	B/I	I	S/I	L/I	I	24	136	3312				40.0	1200	48000						
5	100	1	B/R	B/R	S/R	S/R	S/R	S/R										20	200	4000	30	315	9450
6	101	1	B	B	B	L	B	B/P	35	264	9240												
7	102	1	B/P	P	P	I/P/W	B/I/W	B/I				40	600	24000	12.0	350	4200						
8	103	2	B	B	B	L/I	L	L/I										20	700	14000			
9	105	2	B	B	B	L/I	L	B/L/I	80	414	33120	48	470	22560	20.0	340	6800				33	374	12342
10	105a	2	B/R/F	B/R/F	B/R/F	L/R/F	L/R/F	L/R/F	22	130	2860												
11	106	2	F	F	F	L	B/L	B/B/L				70	370	25900									
12	107	2	B/P/S	B/P/S	B/P/P	L	L	B/L	32	522	16443				28.0	580	16240						
13	108	2	B/P	B/P	B/P	L	B/L	B/L	31.5	609	19183.5												
14	109	2	P	P	P	L	L	B/L	39.4	175	6695												
15	109b	2	P	P	P	B/P	B/P	F	31.5	299	9418.5												
16	110	2	P	P	P	P	P	B/P	39.4	79	3112.6	79	274	21646	63.0	296	18648	39	174	6786	79	373	29467
17	117	2	P	P/B/P	B/P	F	F	F				20	100	2000				47	224	10528	71	348	24708
18	120	2	F	F	F	F	B/S/S	B/F	99	597	59103				29.6	100	2960	117	597	69849	169	398	67262
19	130	2	B/P	B/P	B/P	B/P	B/P	B/P				59	498	29382	56.2	373	20590				46	197	9062
20	132	2	B/P	B/P	P	P	P	B/P	36	547	19692	79	647	51113									
21	134	3	B/P	B/P	B/P	P	P	P										47	498	23406			
22	135	3	F	F	F	F	F	F										102	398	40596	80	299	23920
23	140	3	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	35.5	348	12354	169	282	47658	31.5	394	12411	142	423	60066	99	236	23364
24	141	3	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F							19.7	249	4905						
25	150	3	F	F	F	F	F	F				95	348	33060	23.6	348	8213	91	197	17927			
26	160	3	P	P	P	P	P	F	106	896	95334.4	51	299	15249	19.7	448	8826				79	256	20224
27	170	3	B/P/F	F	F	F	F	F	67	393	26331	43	249	10707	43.4	276	11978	71	299	21229	47	348	16356
28	171	3	B/P/F	F	F	F	F	F				154	324	49896							63	274	17262
29	171.5	3	F	F	F	F	F	F										91	498	45318	79	394	31126
30	172	4	B/P	B/P	B/P	P	P	S/P	55.2	610	33672	27.5	79	2172.5	118.0	456	53808	118	448	52864	43	342	14706
31	173	4	P	P	P	I	B/I	B/I							24.0	158	3792	47	323	15181	71	474	33654
32	175	4	P	P	P	I	B/I	B/I	27.6	199	5492.4				69.0	315	21735						
33	180	4	F	F	F	P	B/P	B/P							158.0	45	7110	19	118	2242	30	257	7710
34	190	4	F	F	F	F	F	F	70.9	299	21199.1	43.3	323	13985.9	55.0	473	26015	39	498	19422	37	473	17501
35	195	4	F	F	F	F	F	F	39.4	236	9298.4				47.0	373	17531						
36	200	5	B/P	B/P	B/P	B/P	B/P	B/P							27.0	348	9396				39	197	7683
37	205	5	F	F	F	F	F	F							47.0	199	9353						
38	210	5	P	P	P	P	P	P	19.7	118	2324.6	98.5	498	49053	106.0	647	68582				26	866	21650
39	220	5	F	F	F	F	F	F													79	800	63200
40	225	5	F	F	F	F	F	F				78.8	348	27422.4									
41	230	5	B/P	B/P	B/P	B/P	B/P	B/P	86.7	348	30171.6				71.0	473	33583				40	315	12600
42	235	6	F	F	F	F	F	F	39.4	199	7840.6	26.3	315.2	8277.15				20	749	14980	79	275	21725
43	240	6	F	F	F	F	F	F	70	500	35000	75.5	500	37760	33.0	473	15609	45	158	7110	69	275	18975
44	260	6	P	P	P	P	P	P	24	512	12288	20	236.4	4728	71.0	315	22365	79	355	28045	69	315	21735
45	270	7	P	P	B/S	B/S	B/S	B/S	31.5	235	7402.5	35.3	709.2	25034.8	79.0	158	12482				60	280	16800
46	280	7	F	F	B/P	B/P	B/P	B/P	55	335	18425	51	315	16065				30	355	10650	39	278	10764

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
47	285	7	F	F	F	F	F	F													112	630	70660
48	300	8	P/F	P/F	R/S/F	R/F	S/F	B/R/P	55.2	624	34444.8	39.4	217	8549.8	10.0	177	1770						
49	320	8	P/F	P/F	R/S/F	R/F	S/F	B/R/P	39.4	323	12726.2												
50	330	8	P	P	P	P	P	P	55.2	547	30194.4	53.2	249	13244.3							40	433	17320
51	350	9	P	P	P	P	P	P													30	276	8280
52	360	10	B/P/F	B/P/F	B/P/F	B/P/F	B/P/F	B/P/F				35.5	100	3550				10	197	1970	20	40	800
53	361	10	B/P	B/P	B/P	B/P	B/P	B/P							20.0	197	3940				20	315	6300
54	370	10	F	F	F	B/S/F	F	F							52.0	335	17420				39	315	12285
55	379	10	F	F	F	F	F	F				27.6	249	6872.4									
56	380	10	P/F	P/F	P/F	P/F	P/F	F/F				39	126	4914	22.0	296	6512				30	433	12990
57	390	10	P	P	P	P	P	P							20.0	236	4720						
58	400	11	P	P	P	P	P	P				25	236	5900	16.0	542	8130						
59	410	12	B/R	B/R	B/R	B/R	B/R	B/R													59	197	11623
60	420	13	B/L/R	B/L/R	B/L/R	B/L/R	B/L/R	B/L/R										39	158	6162			
61	421	13	B/P	B/P	B/P	B/P	B/P	B/P	34	498	16932												
62	428	13	P/B/P	P/B/P	P/B/P	P/B/P	B/P	B/P	26	249	6474												
63	430	13	B/P	B/P	B/P	B/P	B/P	B/P	51	547	27897				26.0	400	10400	26	197	5437.2	24	299	7176
64	435	13	P	P	B/P	B/P	B/P	B/P				36	197	6993.5							20	138	2760
65	440	14	P/B/P	P/B/P	P/B/P	P/B/P	P/B/P	P/B/P	37	249	9213							32	158	4977	20	276	5520
66	460	15	B/S/R/I	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F							24.0	591	14184				60	394	23640
67	463	15	B/S	F	P/F	P/F	F	F	47	749	35203												
68	465	16	P/F	P/F	P/F	P/F	B/F	B/F	39	99	3861												
69	470	16	B/S	B/F	B/F	B/F	B/P	B/P										39	197	7683			
70	480	16	P/F	P/F	P/F	P/F	P/F	B/F										63	299	18837	32	355	11360
71	485	18	B/P	B/P	B/P	B/P	B/P	B/P	34	323	10982												
72	488	17	B/P	B/P	B/P	B/P	B/P	B/P	25	118	2950												
73	490	17	P/B/P	B/P	P/B/P	P/B/P	P/B/P	B/P				79	279	21985.2	51.0	158	8058	39	373	14547			
74	500	17	B/P	B/P	P	P	P	P							62.0	200	12400	67	423	28341	51	158	8089.6
75	510	17	B/P	B/P	B/P	B/P	B/P	B/P							39.0	750	29250	28	423	11674.8			
76	520	17	B/R	B/R	B/R	B/R	R/P	R/P				43	348	15066.4				20	160	3200	28	512	14131.2
77	530	17	B/P	B/P	B/P	B/P	B/P	B/P							39.0	500	19500						
78	532	17	B/P	B/P	B/P	B/P	B/P	B/P				67	423	28341									
79	535	17	B/P/R/I	B/P/R/I	B/P/R/I	B/P/R/I	B/P/R/I	B/P/R/I	126	498	62748	43	99	4265.05							59	448	26476.8
80	536a	17	P/B	P/B	P/B	P/B	B	B				51	348	17817.6									
81	536b	17	F	F	F	F	F	F	63	286	18018	32	118	3717									
82	537a	17	P/B	P/B	P/B	P/B	B	B/P	36	299	10764	32	500	15750									
83	537b	17	B	B	B	B	B	B				35	498	17629.2									
84	538	18	F	F	F	F	F	B/P	33	224	7392	47	79	3728.8				28	498	13744.8			
85	539	18	B/P	B/P	B/P	B/P	B/P	B/P				26	373	10444				43	697	29971			
86	540	18	P	P	B/P	B/P	B/P	B/P	75	355	26589.5	59	197	11623				32	236	7434	39	236	9204
87	546	18	P	P	P	P	P	P							67.0	591	39597						
88	550	18	F	F	F	F	F	F							34.0	630	21420						
89	560	19	F	B/S	P/B/P	B/P	L	L				55	846	46614.6									
90	565	19	F	F	F	F	L/R/L	L/R/L													40	400	16000
91	590	19	P	P	P	P	P	P				43	348	15068.4				47	299	14053	47	552	26109.6
92	595	19	F	F	F/R/F	F/R/F	F/R/F	F/R/F													37	788	29156

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
93	602	19	F	B/S	B/S	B/F	B/F	F	32	749	23968										10	315	3150
94	605	19	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F													20	236	4720
95	610	20	F	F	B/S	B/F	B/F	B/F				75	197	14775							20	158	3160
96	620	20	B/R/B/	B/R/B/	B/R/B/	B/R/B/	B/R/B/	B/R/B/P				20	118	2360				32	99	3102.75	39	138	5382
97	625	20	F	F	F	F	F	F													55	394	21670
98	630	20	B/R/B	B/R/B	B/R/B	B/R/B	B/R/B	B/R/B	35	740	25900							63	299	18837	59	256	15104
99	640	20	B/P	B/P	B/P	B/P	P	P	118	355	41961	43	597	25671	16.0	250	4000	146	398	58108	41	552	22632
100	641	20	F	F	F	F	F	F				91	335	30465									
101	650	21	F	F	F	F	F	F				87	256	22272	39.0	158	6162				12	709	8508
102	670	22	B/P	B/P	P	P	P	P							23.0	493	11339	32	315	10080	72	788	56736
103	680	22	F	F	F	F	F	F													30	276	8280
104	690	22	B/P	B/P	F	F	F	F							34.0	512	17408	36	746	26483	70	236	16520
105	700	22	F	F	F	F	F	F				63	299	18837	39.0	400	15600	95	299	28405	75	394	29550
106	710	22	B/P	B/P	F	F	F	F				36	547	19692							20	315	6300
107	718	23	P/B/P	B/P	B/P	B/P	B/P	B/P	32	599	19168	26	229	5954									
108	730	23	S	F	F	F	F	B/S										28	433	12124	50	39	1950
109	740	23	F	F	F	F	F	F				25	640	16000							29	70	2030
110	744	24	F	F	F	F	F	F							37.0	1150	42550						
111	749	24	F	F	F	F	F	F	37	453	16761	44	540	23760	70.0	236	16520						
112	750	24	F	F	F	F	F	F				26	177	4602				33	158	5214	35	158	5530
113	760	24	B/P	P/B/P	P	P	P	P													32	985	31520
114	770	24	F	F	F	F	F	F/DMD										47	276	12972	75	335	25125
115	772	24	B/P	B/P	B/P	B/P	B/P	B/P													10	158	1580
116	780	25	B/P	B/P	B/P	B/P	B/P	B/P				47	355	16685	28.0	335	9380	58	296	17168	39	118	4602
117	790	25	B/S	B/F	B/F	B/S	F	F				48	600	28800	61.0	426	25986	34	350	11900	66	394	26004
118	800	25	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	33	721	23793				32.0	450	14400	36	551	19836	39	827	32253
119	810	25	B/S	B/F	B/F	B/F	F	B/S				43	760	32680	32.0	512	16384	30	551	16530			
120	814	25	F	F	F	F	F	B										19	315	5985			
121	815	25	F	F	F	F	F	B/S	21	433	9093				18.0	256	4608				35	749	26215
122	818	25	B/S	B/F	B/F	B/F	F	B/S							22.5	536	12060				39	197	7683
123	820	26	F	F	F	B/R/F	B/S/R/	B/B/R/F							28.0	529	14812	47	220	10340	41	355	14555
124	826	26	F	F	F	B/R/F	B/R/S	B/R/F	22	260	5720												
125	828	26	B/S	B/F	B/F	B/F	F	B/S													39	394	15366
126	830	26	F	F	F	F	F	B/S	24	176	4224							21	156	3276	10	118	1180
127	840	27	F	F	F	F	B/S	B/F	32	177	5664							39	276	10764	55	315	17325
128	838	27	F	F	F	F	F	F	20	290	5800										36	197	6895
129	850	27	F	F	F	F	F	F	62	335	20770	35	117	4095	35.0	590	20650	53	480	25440			
130	860	27	S	F	F	F	B/R	B/R	55	156	8580							30	240	7200	57	276	15732
131	870	27	F	F	F	F	F	F				53	181	9593				28	480	13440			
132	880	27	F	F	F	F	F	F				22	189	4158	39.0	137	5343				10	276	2760
133	886	27	S/F	F	F	F	F	F				35	213	7455				24	288	6912	39	252	9828
134	890	27	F	F	F	F	F	F				93	307	28551	37.0	200	7400	16	118	1888	39	197	7683
135	895	27	F	F	F	F	F	F										29	394	11426	55	867	47685
136	896	27	S/R/F	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	26	378	9828	22	118	2596	24.0	190	4560	22	300	6600	29	355	10295
137	897	29	B/R/S	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F										45	371	16695	45	457	20565
138	898	29	B/S/F	B/S/F	F	F	F	F				32	169	5408	54.0	315	17010						

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
139	899	30	F/F	F/F	F/F	F/F	F	F				43	229	9847				16	371	5936			
140	900	30	F	F	B/P	B/P	B/P	B/P				16	276	4416	36.0	355	12425	46	137	6302			
141	910	30	F/B/P	F/B/P	P	P	P	P													20	118	2360
142	920	30	B/P	B/P	B/P	B/P	B/P	P	15	316	4725	35	244	8540				37	176	6512			
143	930	30	F/B/P	F/B/P	P	P	P	P							30.0	293	8790				39	236	9204
144	940	30	B/P	B/P	B/P	B/P	P	P	45	465	20925				26.0	433	11258	16	646	8736			
145	950	30	B/P	B/P	B/P	P	P	P	10	102	1020	16	205	3280	24.0	405	9720				39	138	5382
146	959	30	B/S/F	F	F	F	F	F										42	172	7224			
147	960	30	B/P	B/P	B/P	B/P	B/P	F	39	433	16867	28	1320	36960							20	254	5080
148	980	30	B/P	B/P	B/P	B/P	B/P	F										39	156	6084	20	394	7880
149	984	30	B/R/S	B/R/S	B/R/S	B/R/S	B/R/F	B/R/F							22.0	276	6072						
150	988	30	B/P	B/S	B/P	B/P	B/P	B/P	29	296	8584												
151	990	30	P/B/P	P/B/P	P/B/P	P/B/P	B/P	B/P				24	610	14640	13.0	158	2054				15	98	1470
152	995	31	P/B/P	P/B/P	P/B/P	P/B/P	B/P	B/P				20	122	2440									
153	1001	31	B/R/P	B/R/P	B/R/P	R/P	R/P	R/P	20	79	1580										'62	371	23002
154	1010	31	F	F	F	F	F	F	60	630	37800												
155	1011	31	B/P	B/P	B/P	B/P	B/P	P				54	785	42390	10.0	197	1970				33	376	12408
156	1013	31	B/P	B/P	B/P	B/P	B/P	B/P				24	176	4224									
157	1016	31	B/P	B/P	B/P	B/P	B/P	B/P													25	315	7875
158	1020	31	F	F	B/S	F	F	F				44	870	38280				20	236	4720	47	1090	51230
159	1021	31	B/P	B/S	B/R/P	B/R/L	B/L/R/L	B/L/R/L	26	276	7176	37	355	13135									
160	1025	32	P	P	P	P	B/P	B/P	36.5	532	19418	33	150	4950							24	217	5208
161	1028	32	B/P	B/P	B/L/R/R	B/L/R/R	B/L/R/R	B/L/R/P				30	680	20400									
162	1030	32	P	P	P	P	P	P							30.0	315	9450				50	197	9850
163	1040	32	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F	B/R/F							33.0	217	7161				28	158	4424
164	1045	32	P	P	P	P/R/P	P/R/P	B/P/R/P				65	670	43550									
165	1050	33	F	F	F	F	F	F	63	650	40950				54.0	690	37260	47	250	11750			
166	1055	33	P/F	P/F	P/F	P/F	P/F	P/F	18	240	4320	70	299	20930									
167	1060	33	P/B/P	P/B/P	P/B/P	P/B/P	P/B/P	P/B/P				20	234	4680				37	433	16021			
168	1068	33	B/P/F	B/P/F	B/P/F	B/P/B/R	B/R/P	B/R/P	63	336	21105	62	603	37386				30	276	8280	30	138	4140
169	1070	34	B	B	B	B	B/F	B/S	49	532	26068	34	370	12580	53.0	473	25069				42	197	8274
170	1080	34	B/F	B/F	S/B/S	F	F	F	28	370	10360	46	300	13800				115	236	27140	79	276	21804
171	1081	34	B	B	B	B	B/F	B/S				68	315	21420				33	165	5446			
172	1082	34	F	F	B	F	F	F				35	158	5530	71.0	197	13987				50	634	31700
173	1083	34	F	F	F	F	F	B/S	79	394	31126	76	276	20700				29	150	4350	47	760	35720
174	1085	34	F	F	B/S	B/S	B/F	B/F	54	355	19170	45	156	7020	46.0	867	39882						
175	1090	34	F/R	F/R	F/R	F/R	B/S/R/S	B/B/R/F				60	394	23640	41.0	260	10660	49	852	41748	99	886	87714
176	1095	34	P	P	P	P	P	P													58	236	13688
177	1100	34	F	F	F	F	F	S	62	512	31744				87.0	680	59160	56	370	20720	47	410	19270
178	1102	35	F/F	F/F	F/F	F/F	F/B/S	B/F										41	370	15170			
179	1110	35	F	B/S	F	F	F	F				38	630	23940	82.0	138	11316						
180	1120	35	F	F	F	F	F	F							98.0	217	21266	62	310	19220	166	600	99600
181	1130	35	F	F	F	F	F	B/S							57.0	138	7866	49	521	25529	79	156	12324
182	1138	35	B	B	B	B	B	B	37	284	10508												
183	1140	35	S	F	F	F	F	F	55	972	53460	29	583	17101.3	56.0	430	24080	60	611	36660			
184	1141	35	F	F	F	F	F	B/S				37	303	11211	68.0	473	32164						

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
185	1145	35	F	F	F	F	F	F										26	197	5122			
186	1150/60	36	F	F	B/S/S	B/S/S	F	F				79	1103	87137	37.0	315	11655	56	156	8736	91	495	45045
187	1170	36	F	F	F	F	F	F				57	130	7410				99	280	27720	75	1135	85125
188	1180	36	F	F	F	F	F	F				68	177	12036				24	236	5664			
189	1190	36	F	F	F	F	F	F	19	510	9690				36.0	640	23040	37	217	8029	49	221	10829
190	1200	36	B/S	B/F	B/F	B/F	B/F	B/F				45	260	11700	24.0	59	1416						
191	1210	37	F	F	S/R	F/R	F/R	F/R				24	530	12720	29.0	394	11426	28	340	9520	28	142	3976
192	1220	37	F/R	F/R	F/R	F/R	F/R	F	24	225	5400	45	236	10620	33.0	118	3894				67	288	19296
193	1230	37	F	S	F/R/F	F/R/F	F/R/F	F/R/F													39	142	5538
194	1235	37	F	F	S	F	F	F				63	433	27279									
195	1240	37	F	F	F	F	F	F	25	788	19700							81	430	34830	32	217	6944
196	1250	37	F	B/S	S	F	F	F				30	275	8250							28	130	3640
197	1270	38	F	S/R/F	F/R/F	F/R/F	F/R/F	F/R/F										32	870	27840	34	940	31960
198	1271	38	F	F	S/R/S	F	F	F/R/F	28	197	5516												
199	1275	38	F	B/F	B/F	B	B	B/F	49	276	13524				16.0	137	2192				120	650	78000
200	1276	38	F	F	F	F	F	F	83	116	9794				55.0	254	13970						
201	1277	38	B/P/F	B/P/F	F	F	F	F/R							38.0	312	11856						
202	1278	38	B/S	B/S	B/F	B/F	B/F	B/F				26	106	2756	33.0	500	16500	18	138	2484			
203	1279	39	B/P	B/P	B/P	B/P	B/P	B/P	39	630	24570							27	347	9369	24	252	6048
204	1280	39	B/P/R/I	B/P/R/I	B/L/R/F	B/L/R/F	B/L/R/F	B/L/R/F										30	716	21480	25	366	9150
205	1289	39	F	F	F	F	F	F				29	284	8236									
206	1290	39	B/P	F	F	F	F	F				66	510	33660							67	205	13735
207	1300	39	B/P	B/P	B/P	B/P	F	F													63	420	26460
208	1310	39	B/P	F	F	F	F	F				34	355	12070				35	315	11025	106	503	53318
209	1320	39	B/P	B/P	P/B/P	P/B/P	P/B/P	F				27	358	9666	92.0	156	14352				67	470	31490
210	1321	40	B/P	B/P	B/P	B/P	B/P	B/P										26	236	6136			
211	1330	40	F	S	F	F/F	F	F							32.0	335	10720				30	71	2130
212	1340	40	F	S/F	F	F	F	F	39	414	16146	30	409	12270							41	290	11890
213	1350	40	F	S	F	F/F	F	F							28.0	315	8820				30	217	6510
214	1360	40	F	F	F	F	B/S	B/F	41	236	9676				20.0	110	2200	40	480	19200			
215	1370	40	F	S	F	F/F	F	F				20	356	7120	29.0	520	15080						
216	1390	41	F	F	F	F	B/S	B/F	41	433	17753												
217	1400	41	F	B/R/S	B/R/F	B/R/F	B/R/F	B/R/F							28.0	480	13440						
218	1410	41	F	F	F	F	B/S	B/F															
219	1420	41	F	F	F	F	F	F							32.0	311	9952						
220	1430	41	F	F	F	S	F	F													34	307	10438
221	1440	42	F	F	F	S	F	F	83	790	65570				57.0	209	11913	21	280	5880	34	327	11118
222	1442	42	F	F	S	S	S	S							26.0	50	1300	24	154	3696	33	410	13530
223	1450	42	F	S	F	F	F	F	40	394	15760	50	118	5900	24.0	480	11520				68	860	58480
224	1460	42	F	F	F	S	S/B/S	F	56	356	19936				25.0	362	9050						
225	1465	42	F	F	F	F	F	F															
226																							
227								TOTAL	3878	33951	1637093	4980	37511	1839995	4070	35934	1484511	4167	31666	1477235	6092	46321	2433357
228								MEAN	44.6	390.2	18817.2	47.4	357.3	17523.8	41.5	366.7	15148.1	44.8	340.5	15884.2	47.97	364.7	19160.3
229								N	87	87	87	105	105	105	98	98	98	93	93	93	127	127	127

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Table A-3: 1981-1991 Bank Erosion Calculations

Calculations use data from aerial photo measurements (from Table A-2), 1993 field data (from Table A-5), and McNicholas *(1984)*.

Columns A-B: Erosion site number (Column A) and segments (Columns B), shown on maps, Figure A-1.

Column C-D: Estimated percent bulk composition of bank material that is sand and finer (Column C) and gravel and coarser (Column D), based on field observations supplemented by information from McNicholas *(1984)*.

Columns E-F: Riparian vegetation (see Tables A-1 and A-6 for explanation).

Columns G-I: Bank height, as reported by McNicholas *(1984)*, measured in 1993 (Column H), and best estimate used in calculation (Column I).

Columns J-K: Width (lateral recession) (Column J) and length (Column K) of eroded bank as measured from photos, and volume in cubic yards as the product of H x W x L (Column L).

Columns M-N: Volume in cubic yards of fine (Column M) and coarse (Column N) sediment.

1981-1991 Erosion Calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Erosion	Seq	Estimate		Riparian Type			Bank Height		Width	Length	Volume	Volume	Volume
2	Site		Grain Siz		1981	1991	82	93	Est	81-9	81-91	81-91	Fine	Coarse.
3			F	C			(ft)	(ft)	(ft)	(ft)	(ft)	(cy)	(cy)	(cy)
4														
5	100	1	80	20	S/R	S/R	3		3	30	315	1050	840	210
6	105	2	80	20	L	B/L/I			8	33	374	3657	2926	731
7	110	2	95	5	P	B/P	35	75	75	79	373	81853	77760	4093
8	117	2	60	40	F	F		5	5	71	348	4576	2745	1830
9	120	2	60	40	B/S/S	B/F	6		6	169	398	14947	8968	5979
10	130	2	15	85	B/P	B/P	8	8	8	46	197	2685	403	2282
11	135	3	95	5	F	F		5	5	80	299	4430	4208	221
12	140	3	75	25	B/R/F	B/R/F	6		6	99	236	5192	3894	1298
13	160	3	90	10	P	F	7	9	9	79	256	6741	6067	674
14	170	3	50	50	F	F	7	8	8	47	348	4846	2423	2423
15	171	3	50	50	F	F		8	8	63	274	5115	2557	2557
16	171.5	3	50	50	F	F			8	79	394	9223	4611	4611
17	172	4	100	0	P	S/P		7	7	43	342	3813	3813	0
18	173	4	100	0	B/I	B/I			7	71	474	8725	8725	0
19	*180*	*4*	*75*	*25*	*B/P*	*B/P*	*40*	*50*	*50*	*30*	*257*	*14278*	*10708*	*3569*
20	190	4	85	15	F	F	8	12	12	37	473	7778	6611	1167
21	200	5	70	30	B/P	B/P	35	40	40	39	197	11382	7968	3415
22	210	5	90	10	P	P	7	10	10	25	866	8019	7217	802
23	220	5	100	0	F	F	8	6	6	79	800	14044	14044	0
24	230	5	100	0	B/P	B/P	7	9	9	40	315	4200	4200	0
25	235	6	100	0	F	F			9	79	275	7242	7242	0
26	240	6	60	40	F	F	30	12	12	69	275	8433	5060	3373
27	260	6	90	10	P	P	7	8	8	69	315	6440	5796	644
28	270	7	100	0	B/S	B/S	8		8	60	280	4978	4978	0
29	280	7	60	40	B/P	B/P	8	9	9	39	276	3588	2153	1435
30	285	7	100	0	F	F		8	8	112	630	20907	20907	0
31	330	8	80	20	P	P	8		8	40	433	5132	4105	1026
32	350	9	90	10	P	P	8		8	30	276	2453	2208	245
33	360	10	95	5	B/P/F	B/P/F	6	12	12	20	40	356	338	18
34	361	10	100	0	B/P	B/P		10	10	20	315	2333	2333	0
35	370	10	90	10	F	F	10	10	10	39	315	4550	4095	455
36	*380*	*10*	*70*	*30*	*P/F*	*F/F*	*8*	*8*	*8*	*30*	*433*	*3849*	*2694*	*1155*
37	410	13	50	50	B/R	B/R	8	15	15	59	197	6457	3229	3229
38	430	13	90	10	B/P	B/P	8	8	8	24	299	2126	1914	213
39	435	13	95	5	B/P	B/P		10	10	20	138	1022	971	51
40	440	14	80	20	P/B/P	P/B/P	8	10	10	20	276	2044	1636	409
41	460	15	90	10	B/R/F	B/R/F	8	11	11	60	394	9631	8668	963
42	480	16	75	25	P/F	B/F	4.5		5	32	355	1893	1420	473
43	500	17	100	0	P	P	8	6	8	51	158	2397	2397	0
44	520	17	90	10	R/P	R/P	6	6	6	28	512	3140	2826	314
45	535	17	100	0	B/P/R/P	B/P/R/P		5	5	59	448	4903	4903	0
46	540	18	100	0	B/P	B/P	7	6	6	39	236	2045	2045	0
47	565	19	75	25	L/R/L	L/R/L		*20*	20	40	400	*11852*	*8889*	2963
48	590	19	100	0	P	P	6	40	40	47	552	38681	38681	0
49	595	19	75	25	F/R/F	F/R/F		15	15	37	788	16198	12148	4049
50	602	20	50	50	B/F	F		30	30	10	315	3500	1750	1750
51	605	20	100	0	B/R/F	B/R/F		8	8	20	236	1399	1399	0
52	610	20	15	85	B/F	B/F	15		15	20	158	1756	263	1492

1981-1991 Erosion Calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
53	620	20	35	65	B/R/B/P	B/R/B/P	8	8	8	39	138	1595	558	1037
54	625	20	85	15	F	F		7	7	55	394	5618	4775	843
55	630	20	85	15	B/R/B	B/R/B	6	6	6	59	256	3356	2853	503
56	640	20	100	0	P	P	6		6	41	552	5029	5029	0
57	650	21	100	0	F	F	5	5	5	12	709	1576	1576	0
58	670	22	100	0	P	P	6	6	6	72	788	12608	12608	0
59	680	22	90	10	F	F	8	7	7	30	276	2147	1932	215
60	690	22	25	75	F	F	15	20	20	70	236	12237	3059	9178
61	700	22	100	0	F	F	4	6	6	75	394	6567	6567	0
62	710	22	20	80	F	F	12	18	18	20	315	4200	840	3360
63	730	23	100	0	F	B/S	5		5	50	39	361	361	0
64	740	23	85	15	F	F	6		6	29	70	451	383	68
65	750	24	100	0	F	F	6		6	35	158	1229	1229	0
66	760	24	100	0	P	P	7		7	32	985	8172	8172	0
67	770	24	80	20	F	F/DMD	8		8	75	335	7444	5956	1489
68	772	24	80	20	B/P	B/P			8	10	158	468	375	94
69	780	25	80	20	B/P	B/P	9		9	39	118	1534	1227	307
70	790	25	35	65	F	F	5		5	66	394	4816	1685	3130
71	800	25	65	35	B/R/F	B/R/F	7		7	39	827	8362	5435	2927
72	815	25	100	0	F	B/S			6	35	749	5826	5826	0
73	818	25	80	20	F	B/S			6	39	197	1707	1366	341
74	820	26	50	50	B/S/R/S	B/B/R/F	6		6	41	355	3234	1617	1617
75	828	26	75	25	F	B/S			8	39	394	4553	3415	1138
76	830	26	75	25	F	B/S	8		8	10	118	350	262	87
77	840	27	80	20	B/S	B/F	5		5	55	315	3208	2567	642
78	838	27	80	20	F	F			6	35	197	1532	1226	306
79	860	27	90	10	B/R	B/R	6		6	57	276	3496	3146	350
80	880	27	100	0	F	F	6		6	10	276	613	613	0
81	888	27	60	40	F	F			6	39	252	2184	1310	874
82	890	27	60	40	F	F	5		5	39	197	1423	854	569
83	895	27	80	20	F	F			5	55	867	8831	7064	1766
84	896	27	80	20	B/R/F	B/R/F			5	29	355	1906	1525	381
85	897	29	80	20	B/R/F	B/R/F			6	45	457	4570	3656	914
86	910	30	100	0	P	P	7		7	20	118	612	612	0
87	930	30	85	15	P	P	6		6	39	236	2045	1739	307
88	950	30	100	0	P	P	10		10	39	138	1993	1993	0
89	960	30	100	0	B/P	F	10		10	20	254	1881	1881	0
90	980	30	100	0	B/P	F	10		10	20	394	2919	2919	0
91	990	30	100	0	B/P	B/P	4.5		5	15	98	245	245	0
92	1001	31	100	0	R/P	R/P			6	62	371	5112	5112	0
93	1011	31	100	0	B/P	P			6	33	376	2757	2757	0
94	1015	31	100	0	B/P	B/P			5	25	315	1458	1458	0
95	1020	31	100	0	F	F	5		5	47	1090	9487	9487	0
96	1025	32	80	20	B/P	B/P			10	24	217	1929	1543	386
97	1030	32	20	80	P	P	8	13	13	50	197	4743	949	3794
98	1040	32	100	0	B/R/F	B/R/F	7	20	20	28	158	3277	3277	0
99	1068	33	95	5	B/R/P	B/R/P			7	30	138	1073	1020	54
100	1070	34	95	5	B/F	B/S	4.5	7.5	8	42	197	2298	2183	115
101	1080	34	85	15	F	F	5	9	9	79	276	7268	6178	1090
102	1082	34	80	20	F	F		6	6	50	634	7044	5636	1409
103	1083	34	80	20	F	B/S		6	6	47	760	7938	6350	1588
104	1090	34	85	15	B/S/R/S	B/B/R/F	8	10	10	99	886	32487	27614	4873

1981-1991 Erosion Calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
105	1095	34	80	20	P	P		33	33	58	236	16730	13384	3346
106	1100	34	80	20	F	S	5		5	47	410	3569	2855	714
107	1120	35	50	50	F	F	4.5		5	166	600	16600	8300	8300
108	1130	35	25	75	F	B/S	4	5	5	79	156	2282	571	1712
109	150/6(	36	60	40	F	F	6.5	8	8	91	495	13347	8008	5339
110	*1170*	36	*100*	*0*	F	F	*5*		*5*	*75*	*1135*	*15764*	*15764*	*0*
111	1190	36	40	60	F	F	6	9	9	49	221	3610	1444	2166
112	1210	37	90	10	F/R	F/R	50	55	55	28	142	8099	7289	810
113	1220	37	60	40	F/R	F	8	10	10	67	288	7147	4288	2859
114	1230	37	100	0	F/R/F	F/R/F	5	4	4	39	142	820	820	0
115	1240	37	80	20	F	F	30	30	30	32	217	7716	6172	1543
116	1250	37	70	30	F	F	60	90	90	28	130	12133	8493	3640
117	1270	38	65	35	F/R/F	F/R/F	8	8	8	34	940	9470	6155	3314
118	1275	38	70	30	B	B/F		6	6	120	650	17333	12133	5200
119	1279	39	70	30	B/P	B/P		3	3	24	252	672	470	202
120	1280	39	5	95	B/L/R/F	B/L/R/F	5	5	5	25	366	1694	85	1610
121	1290	39	50	50	F	F	4		4	67	205	2035	1017	1017
122	1300	39	30	70	F	F	4		4	63	420	3920	1176	2744
123	1310	39	80	20	F	F	6	10	10	106	503	19747	15798	3949
124	1320	39	85	15	P/B/P	F	7	7	7	67	470	8164	6939	1225
125	1330	40	60	40	F	F	5	10	*10*	*30*	*71*	*789*	*473*	*316*
126	1340	40	45	55	F	F	5	7	7	41	290	3083	1387	1695
127	1350	40	40	60	F	F	4	6	6	30	217	1447	579	868
128	1430	41	75	25	F	F	30	50	50	34	307	19330	14497	4832
129	1440	42	95	5	F	F	20	50	50	34	327	20589	19559	1029
130	1442	42	95	5	S	S			6	33	410	3007	2856	150
131	1450	42	95	5	F	F	4	12	12	68	860	25991	24692	1300
132														
133						TOTAL					46321	868714	702963	165751
134						AVERAGI	9.8	15.0	11.4	48	365	6840	5535	1305
135						N	90	73	127	127	127	127	127	127

Table A-4: 1972-1981 Bank Erosion Calculations

Calculations use data from aerial photo measurements (from Table A-2), 1993 field data (from Table A-5), and McNicholas *(1984)*.

Columns A-B: Erosion site number (Column A) and segments (Columns B), shown on maps, Figure A-1.

Column C-D: Estimated percent bulk composition of bank material that is sand and finer (Column C) and gravel and coarser (Column D), based on field observations supplemented by information from McNicholas *(1984)*.

Columns E-F: Riparian vegetation (see Tables A-1 and A-6 for explanation).

Columns G-I: Bank height, as reported by McNicholas *(1984)*, measured in 1993 (Column H), and best estimate used in calculation (Column I).

Columns J-K: Width (lateral recession) (Column J) and length (Column K) of eroded bank as measured from photos, and volume in cubic yards as the product of H x W x L (Column L).

Columns M-N: Volume in cubic yards of fine (Column M) and coarse (Column N) sediment.

Columns O-Q: Volume computations from McNicholas *(1984)*.

1972-1981 Erosion Calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	NOTE: Asterisk indicates data from McNicholas (1984).																
2																	
3	Erosion	Seg	Estimated		Riparian Type			Bank height		Width	Length	Volume	Volume	Volume	*Width	*Lengt	*Volume
4	Site		Grain Size		1972	1981	*82	93	Est	72-81	72-81	72-81	F	C	72-81	72-81	72-81
5			F	C			(ft)	(ft)	(ft)	(ft)	(ft)	(cy)	(cy)	(cy)	(ft)	(ft)	(cy)
6																	
7	100	1	80	20	S/R	S/R	3		3	20	200	444	356	89	5	300	150
8	103	2	80	20	L/I	L			6	20	700	3111	2489	622			
9	110	2	95	5	P	P	35	75	35	39	174	8797	8357	440	36	200	9333
10	117	2	60	40	F	F		5	5	47	224	1950	1170	780			
11	120	2	60	40	F	B/S/S	6		6	117	597	15522	9313	6209	9	600	1200
12	130	2	15	85	B/P	B/P	8	8	8						3	150	120
13	134	3	95	5	P	P			6	47	498	5201	4941	260			
14	135	3	95	5	F	F		5	5	102	398	7518	7142	376			
15	140	3	75	25	B/R/F	B/R/F	6		6	142	423	13348	10011	3337	72	500	8000
16	150	3	90	10	F	F	7	9	7	91	197	4648	4183	465	9	150	350
17	160	3	90	10	P	P	7	9	7						54	300	4200
18	170	3	50	50	F	F	7	8	7	71	299	5504	2752	2752	27	675	4725
19	171b	3	50	50	F	F			8	91	498	13428	6714	6714			
20	172	4	100	0	P	P		7	7	118	448	13705	13705	0			
21	173	4	100	0	I	B/I			7	47	323	3936	3936	0			
22	180	4	75	25	P	B/P	40	50	40	19	118	3321	2491	830	5	125	833
23	190	4	85	15	F	F	8	12	8	39	498	5755	4891	863	45	700	9333
24	200	5	70	30	B/P	B/P	35	40	35						7	125	1167
25	210	5	90	10	P	P	7	10	7						45	850	9917
26	220	5	100	0	F	F	8	6	8						1	650	173
27	230	5	100	0	B/P	B/P	7	9	7						2	300	140
28	235	6	100	0	F	F			9	20	749	4993	4993	0			
29	240	6	60	40	F	F	30	12	30	45	158	7900	4740	3160	14	100	1500
30	250	6	50	50	F	F	20	30	20						1	125	83
31	260	6	90	10	P	P	7	8	7	79	355	7271	6544	727	5	550	642
32	270	7	100	0	B/S	B/S	8		8						3	350	280
33	280	7	60	40	B/P	B/P	8	9	8	30	355	3156	1893	1262	2	650	347
34	290	8	40	60	F	B/P/F	12		12						1	550	220
35	300	8	50	50	R/F	S/F	8		8						1	600	160
36	310	8	90	10	R/F	S/F	9		9						2	300	180
37	320	8	90	10	R/F	S/F	9		9						9	150	450
38	330	8	80	20	P	P	8		8						9	200	533
39	340	9	90	10	R/F	F	8	6	8						2	250	133
40	350	9	90	10	P	P	8		8						3	75	60
41	360	10	95	5	B/P/F	B/P/F	6	12	6	10	197	438	416	22	1	500	100
42	370	10	90	10	B/S/F	F	10	10	10						1	150	50
43	380	10	70	30	P/F	P/F	8	8	8						3	300	240
44	390	10	80	20	P	P	3		3						5	500	250
45	400	11	80	20	P	P	8		8						27	150	1200
46	410	12	50	50	B/R	B/R	8	15	8						5	250	333
47	420	13	90	10	B/L/R	B/L/R	8	7	8	39	158	1826	1643	183	18	450	2400
48	430	13	90	10	B/P	B/P	8	8	8	28	197	1611	1450	161	27	250	2000
49	440	14	80	20	P/B/P	P/B/P	8	10	8	32	158	1475	1180	295	5	300	400
50	450	14	80	20	B/P	B/P	8	10	8						1	150	40
51	460	15	90	10	B/R/F	B/R/F	8	11	8						1	200	53
52	470	16	85	15	B/F	B/P	5		5	39	197	1281	1088	192	27	500	2250
53	480	16	75	25	P/F	P/F	5		5	63	299	3140	2355	785	27	500	2250
54	490	17	100	0	P/B/P	P/B/P	7		7	39	373	3771	3771	0	27	550	3850
55	500	17	100	0	P	P	8	6	8	67	423	8397	8397	0	18	700	3733
56	510	17	75	25	B/P	B/P	6	5	6	28	423	2594	1946	649	9	550	1100
57	520	17	90	10	B/R	R/P	6	6	6	20	160	711	640	71	5	75	75
58	530	17	75	25	B/P	B/P	6		6						4	300	240
59	538	18	100	0	F	F			6	28	498	3054	3054	0			
60	539	18	100	0	B/P	B/P			6	43	697	6660	6660	0			
61	540	18	100	0	B/P	B/P	7	6	7	32	236	1927	1927	0	3	200	140

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1972-1981 Erosion Calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
62	548	18	80	20	P	P		6	6								
63	550	18	80	20	F	F	6		6						3	1000	600
64	560	19	48	52	B/P	L	45	50	45						5	550	4125
65	570	19	85	15	F	F	8		8						3	200	160
66	580	19	30	70	B/R/P	B/R/P	7	25	7						2	200	93
67	590	19	100	0	P	P	6	40	6	47	299	3123	3123	0	11	450	1080
68	600	19	50	50	B/R/F	B/R/F	6	7	6						4	300	240
69	610	20	15	85	B/F	B/F	15		15						5	200	500
70	620	20	35	65	B/R/B/P	B/R/B/P	8	8	8	32	99	919	322	598	9	125	333
71	630	20	85	15	B/R/B	B/R/B	6	6	6	63	299	4186	3558	628	27	650	3900
72	640	20	100	0	B/P	P	6		6	146	398	12913	12913	0	54	600	7200
73	650	21	100	0	F	F	5	5	5						27	300	1500
74	660	21	90	10	F	F	6		6						45	400	4000
75	670	22	100	0	P	P	6	6	6	32	315	2240	2240	0	5	650	650
76	680	22	90	10	F	F	8	7	8						4	400	427
77	690	22	25	75	F	F	15	20	15	36	746	14713	3678	11035	4	200	400
78	700	22	100	0	F	F	4	6	4	95	299	4208	4208	0	72	600	6400
79	710	22	20	80	F	F	12	18	12						2	300	240
80	720	23	50	50	B/P	B/P	9		9						1	350	105
81	730	23	100	0	F	F	5		5	28	433	2245	2245	0	1	100	17
82	740	23	85	15	F	F	6		6						2	350	140
83	750	24	100	0	F	F	6		6	33	158	1159	1159	0	18	350	1400
84	760	24	100	0	P	P	7		7						32	800	6533
85	770	24	80	20	F	F	8		8	47	276	3844	3075	769	36	400	4267
86	780	25	80	20	B/P	B/P	9		9	58	296	5723	4578	1145	54	650	11700
87	790	25	35	65	B/S	F	5		5	34	350	2204	771	1432	54	600	6000
88	800	25	65	35	B/R/F	B/R/F	7		7	36	551	5143	3343	1800	14	450	1575
89	810	25	100	0	B/F	F	6		6	30	551	3673	3673	0	18	1000	4000
90	814		100	0	F	F			6	30	551	3673	3673	0			
91	815		100	0	F	F			6	19	315	1330	1330	0			
92	820	26	50	50	B/R/F	B/S/R/S	6		6	47	220	2298	1149	1149	2	820	328
93	830	26	75	25	F	F	8		8	21	156	971	728	243	1	830	221
94	840	27	80	20	F	B/S	5		5	39	276	1993	1595	399	14	350	875
95	850	27	100	0	F	F	6		6	53	480	5853	5853	0	18	300	1200
96	860	27	90	10	F	B/R	6		6	30	240	1600	1440	160	18	350	1400
97	870	27	100	0	F	F	5		5	28	480	2489	2489	0	9	200	333
98	880	27	100	0	F	F	6		6						18	300	1200
99	888	27	60	40	F	F			6	24	288	1536	922	614			
100	890	27	60	40	F	F	5		5	16	118	350	210	140	36	300	2000
101	895	27	80	20	F	F			5	29	394	2116	1693	423			
102	896	27	80	20	B/R/F	B/R/F			5	22	300	1222	978	244			
103	897	29	80	20	B/R/F	B/R/F			8	45	371	3710	2968	742			
104	899.5	30	80	20	F/F	F			7	16	371	1539	1231	308			
105	900	30	100	0	B/P	B/P			7	46	137	1634	1634	0			
106	910	30	100	0	P	P	7		7						5	100	117
107	920	30	100	0	B/P	B/P	7		7	37	176	1686	1686	0	5	100	117
108	930	30	85	15	P	P	6		6						9	350	700
109	940	30	100	0	B/P	P	10		10	16	546	3236	3236	0	4	200	267
110	950	30	100	0	P	P	10		10						4	150	200
111	960	30	100	0	B/P	B/P	10		10	42	172	2676	2676	0	3	100	100
112	970	30	100	0			10		10						3	100	100
113	980	30	100	0	B/P	B/P	10		10	39	156	2253	2253	0	3	100	100
114	990	30	100	0	P/B/P	B/P	5		5						5	250	188
115	1000		100	0			6		6						9	200	400
116	1010	31	100	0	F	F	6		6						9	100	200
117	1020	31	100	0	F	F	5		5	20	236	874	874	0	63	350	4083
118	1030	32	20	80	P	P	8	13	8						9	400	1067
119	1040	32	100	0	B/R/F	B/R/F	7	20	7						23	200	1167
120	1050	33	100	0	F	F	4	6	4	47	250	1741	1741	0	63	550	5133
121	1060	33	15	85	P/B/P	P/B/P	4		4	37	433	2373	356	2017	2	650	173
122	1068	33	95	5	B/P/B/R	B/R/P			7	30	276	2147	2039	107			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
123	1070	34	95	5	B	B/F	5	8	5						90	800	12000
124	1080	34	85	15	F	F	5	9	5	115	236	5026	4272	754	18	800	2667
125	1081	34	80	20	B	B/F			6	33	165	1210	968	242			
126	1083	34	80	20	F	F		6	6	29	150	967	773	193			
127	1090	34	85	15	F/R	B/S/R/S	8	10	8	49	852	12370	10514	1855	36	1500	16000
128	1100	34	80	20	F	F	5		5	56	370	3837	3070	767	72	1150	15333
129	1102	35	80	20	F/F	F/B/S			7	41	370	3933	3146	787			
130	1110	35	45	55	F	F	8	10	8						9	700	1867
131	1120	35	50	50	F	F	5		5	62	310	3203	1602	1602	72	700	8400
132	1130	35	25	75	F	F	4	5	4	49	521	3782	946	2837	27	600	2400
133	1140	35	20	80	F	F	7		7	60	611	9504	1901	7604	18	200	933
134	1145	35	60	40	F	F		8	8	26	197	1518	911	607			
135	1150		60	40			6	8	6						18	450	1800
136	1160	36	65	35	B/S/S	F	7	8	7	56	156	2265	1472	793	63	350	5717
137	1170	36	100	0	F	F	5		5	99	280	5133	5133	0	54	300	3000
138	1180	36	70	30	F	F	65	70	65	24	236	13636	9545	4091	9	200	4333
139	1190	36	40	60	F	F	6	9	6	37	217	1784	714	1071	27	300	1800
140	1200	36	80	20	B/F	B/F	40	55	40						5	250	2000
141	1210	37	90	10	F/R	F/R	50	55	50	28	340	17630	15867	1763	9	350	5833
142	1220	37	60	40	F/R	F/R	8	10	8						36	650	6933
143	1230	37	100	0	F/R/F	F/R/F	5	4	5						5	300	250
144	1240	37	80	20	F	F	30	30	30	81	430	38700	30960	7740	18	100	2000
145	1250	37	70	30	F	F	60	90	60						4	600	4800
146	1260	37	40	60	F	F	15	20	15						14	450	3375
147	1270	38	65	35	F/R/F	F/R/F	8	8	6	32	870	8249	5362	2887	1	600	160
148	1278	38	70	30	B/F	B/F			6	18	138	552	386	166			
149	1279	39	70	30	B/P	B/P		3	3	27	347	1041	729	312			
150	1280	39	5	95	B/L/R/F	B/L/R/F	5	5	5	30	716	3978	199	3779	11	200	400
151	1290	39	50	50	F	F	4		4						63	700	6533
152	1300	39	30	70	B/P	F	4		4						54	250	2000
153	1310	39	80	20	F	F	6	10	6	35	315	2450	1960	490	54	500	6000
154	1320	39	85	15	P/B/P	P/B/P	7	7	7						81	400	8400
155	1321	40	85	15	B/P	B/P			7	26	236	1591	1352	239			
156	1330	40	60	40	F/F	F	5	10	5						45	400	3333
157	1340	40	45	55	F	F	5	7	5						45	400	3333
158	1350	40	40	60	F/F	F	4	6	4						36	300	1600
159	1360	40	30	70	F	B/S	4	15	4	40	480	2844	853	1991	36	125	667
160	1370	40	100	0	F/F	F	12		12						108	375	18000
161	1380		50	50			3		3						5	500	208
162	1390	41	25	75	F	B/S	4	5	4						14	300	600
163	1400	41	20	80	B/R/F	B/R/F	4	35	4						27	400	1800
164	1410	41	60	40	F	B/S	5	10	5						3	400	200
165	1420	41	40	60	F	F	6	6	6						9	450	900
166	1430	41	75	25	S	F	30	50	30						27	275	8250
167	1440	42	95	5	S	F	20	50	20	21	280	4356	4138	218	9	225	1500
168	1442	42	95	5	S	S			6	24	154	821	780	41			
169	1450	42	95	5	F	F	4	12	4						4	250	133
170	1460		100	0			5		5						9	300	500
171	1470	42	0	100	F	F	5	12	5						14	250	625
172	1480	42	70	30	S	S/B/S	6	30	6						2	650	260
173																	
174						TOTAL				4197	32217	432166	334143	98022	2673	54625	330834
175						MEAN	9.8	16.3	9.2	44.6	342.7	4598	3555	1043	19	396	2397
176						N	136	84	166	94.0	94.0	94	94	94	138	138	138

Table A-5. 1993 Observations at Eroding Sites

Column A: Site number (see Figure A-1 for location).

Columns B-C: Height and length of eroding bank.

Columns D-F: Qualitative ranking of the extent and rate of erosion.

Columns G-K: Grain size of bank sediment.

Column L: Percent of bank in contact with large woody debris (LWD).

1993 Field Data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	NOTES:																								
2	Activity Level: (A) Active; (PA) Partially active; (S) Stable.																								
3	Texture: (1) sandy silt; (2) Silty sand; (3) sand, gravel, & cobbles; (4) boulders; (5) bedrock.																								
4	Contributing Factors: (1) Bend; (2) Bar; (3) Trampling; (4) Lack of vegetation; (5) Landslide; (6) LOD.																								
5	Limiting Factors: (1) LWD; (2) Riprap; (3) Revegetation; (4) Channel change; (5) Boulders; (6) Bedroc																								
6																									
7	Erosion	H	L	Activity			Texture					LWD	Rip	Causes						Mitigating Factors					
8	Site	(ft)	(ft)	A	PA	S	1	2	3	4	5	%	rap	1	2	3	4	5	6	1	2	3	4	5	6
9																									
10	110	75	410	X					X			30		X		X	X			X					
11	117	5	110		X				X			10		X			X			X					
12	120	0	0			X	X					0	X								X				
13	130	8	150		X			X	X			10		X						X		X			
14	135	5	200		X		X		X			75		X						X		X			
15	140	0	0			X						50								X			X		
16	150/60	9	250		X				X			25		X						X					
17	170	8	300		X		X		X			50		X						X					
18	171	8	100		X		X		X			25		X						X		X			
19	172	7	120		X				X					X											
20	175	6	500	X			X							X								X			
21	180	50	300	X					X				X	X			X			X					
22	190	12	300		X		X							X											
23	200	40	85	X					X			25		X					X	X					
24	210	10	850	X			X					0		X			X								
25	220	6	85		X		X					33		X						X					
26	230	9	350		X		X							X											
27	240	12	35		X		X							X											
28	250	30	150		X		X							X				X				X			
29	260	8	450		X		X							X			X								
30	270	0	0			X	X					100								X					
31	280	9	300		X		X							X			X								
32	285	8	200		X		X					25		X			X			X					
33	288	11	200		X		X							X								X			
34	290	0	0			X			X														X		
35	300	0	0			X	X						X								X				
36	310	0	0			X	X						X								X				
37	320	0	0			X	X						X								X				
38	330	0	0			X	X		X				X								X				
39	340	6	250		X		X						X	X							X				
40	350	0	0			X	X						X								X				
41	360	12	600	X			X					0		X											
42	361	10	30		X		X					50		X						X					
43	370	10	45		X		X					50		X						X					
44	380	8	420		X		X							X											
45	390	0	0			X			X													X			
46	400	0	0			X	X						X								X				
47	410	15	50		X			X	X			25						X		X		X			
48	414	7	10		X			X																	
49	416	8	40		X			X						X								X			
50	420	7	60		X			X														X			
51	430	8	300		X			X						X								X			
52	435	10	80	X				X	X			60		X			X								
53	440	10	80	X				X	X			0		X			X								
54	450	10	135		X			X	X			60		X						X					
55	460	11	100		X			X				25													
56	470	0	0			X		X					X								X				
57	480	0	0			X		X														X			
58	490	0	0			X		X														X			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
59	500	6	360		X			X				0		X			X				X				
60	510	5	180		X			X				50		X						X		X			
61	520	6	360		X			X	X			5		X			X								
62	530	0	0			X		X				100								X		X			
63	535	5	240		X			X				60		X			X			X					
64	540	6	375		X			X				10			X		X			X					
65	548	6	180		X				X			20		X						X		X			
66	550	0	0			X			X	X													X		
67	560	50	650	X					X	X		5	X	X		X	X								
68	565	20	300	X					X	X		5		X			X					X			
69	570	0	0			X		X														X			
70	580	25	240	X					X	X		0		X								X			
71	590	40	350	X					X	X		15		X			X								
72	592	9	250	X				X				15		X			X								
73	595	15	390		X				X			10		X		X						X			
74	597	8	300		X			X				15			X										
75	600	7	360		X				X			15			X							X			
76	602	30	150	X					X	X		10		X								X			
77	605	8	390		X		X					10		X			X					X			
78	610	0	0			X			X													X	X		
79	620	8	210		X		X		X			0		X								X			
80	625	7	180	X			X					10		X			X			X					
81	630	6	600	X					X			10		X								X			
82	640	0	0			X	X					100								X					
83	650	5	210		X		X					60		X						X					
84	660	0	0			X	X																X		
85	670	6	750	X			X		X	X		0		X			X								
86	680	7	270		X		X					20			X										
87	690	20	300		X				X	X		10		X								X			
88	700	6	450		X			X		X		30		X						X					
89	710	18	300	X					X	X		20		X											
90	720	0	0			X	X		X																
91																									
92	1030	13	550	X					X			5		X		X	X								
93	1040	20	150		X						X	0		X											X
94	1050	8	170		X						X	O		X											X
95	1060	0	0			X	X		X				X								X				
96	1070	7.5	250		X				X			10		X	X							X			
97	1080	9	400		X				X			10		X											
98	1082	6	430		X				X			30		X						X					
99	1083	6	450		X		X		X			20		X											
100	1085	5	360		X				X			20													
101	1090	10	1200	X			X		X			20		X			X								
102	1100	0	0			X	X		X														X		
103	1110	10	230		X				X			0		X											
104	1120	0	0			X			X			90								X					
105	1130	5	540		X				X			10			X										
106	1135	8	780		X		X		X			20			X										
107	1140	0	0			X	X		X			40								X			X		
108	1145	8	550	X			X		X			10		X											
109	1150/60	8	550	X			X		X			25		X			X								
110	1170	0	0			X	X					80								X					
111	1180	70	330	X					X			20		X			X			X					
112	1190	9	860	X			X		X			10		X					X						
113	1200	55	250		X				X	X		0		X				X				X		X	X
114	1205	8	240		X		X		X	X		20			X					X					X
115	1210	55	350	X				X	X			5		X			X						X	X	
116	1220	10	300	X			X		X	X		5			X										
117	1230	4	180		X		X		X	X		20		X			X			X			X		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
118	1235	30	100	X			X		X	X		30		X			X	X		X		X			
119	1240	30	240		X			X				0										X		X	
120	1250	90	600	X				X	X	X		5		X			X	X				X			
121	1260	20	480	X				X	X	X	X	0		X											X
122	1270	8	600		X			X	X	X	X	20		X			X								X
123	1274	6	300		X		X		X			20			X							X			
124	1275	6	50	X				X	X	X		0		X									X		
125	1279	3	130		X			X	X	X		10			X							X			
126	1280	5	200		X					X	X	0		X											X
127	1290	0	0			X			X											X			X		
128	1310	10	400	X				X	X					X											
129	1320	7	320	X					X					X											
130	1330	10	180	X					X					X											
131	1340	7	300	X					X					X											
132	1350	6	300		X				X					X											
133	1360	15	80		X				X					X						X					
134	1370	0	0			X	X	X	X														X		
135	1390	5	250	X				X	X			25		X						X					
136	1400	35	160	X				X	X			25		X						X					
137	1410	10	220	X			X		X					X											
138	1420	6	200	X				X	X					X											
139	1430/40	50	350	X			X		X					X			X	X							
140	1450/60	12	480	X				X	X					X											
141	1470	12	350		X			X	X					X											X
142	1472	8	100		X			X	X					X											
143	1480	30	30		X						X							X				X			X
144	1485	7	90		X						X							X				X			X
145																									
146	AVERAGE	12	236									23													
147	N	134	134	40	66	28	54	39	80	21	7	83		88	11	4	30	8	2	38	11	36	12	3	10
148																									
149	COMMENTS:																								
150	(110; 180; 560) House(s) near edge of terrace.																								
151	*(120; 1060) recent riprap.*																								
152	(670) Tires on bank d/s of site.																								
153	(290) Bend cutoff.																								
154	(660) Channel has moved to other side of bar.																								
155	(625) LWD on d/s end of site.																								
156	(640) Completely protected by LWD.																								
157	(650) Large LWD dam on d/s end.																								
158	(1205) LWD stabilizing d/s end of site.																								
159	(1120; 1170; 1370) Bank protected by LWD.																								
160	(1290) Channel on right side of bar, LWD on d/s end of site may have diverted channel.																								
161	(610; 1100; 1140) Bar protects bank																								
162	(1275) 450 ft of bank protected by bar.																								
163	(1130; 1135; 1279) Bar forces stream against bank.																								
164	(1210) Additional 125 ft of bank u/s protected by bar.																								
165	(540) Tree roots locally stabilize bank.																								
166	(590; 592) Trees on bank recently cut.																								
167	(710) Plantation forest.																								
168	(1270) Clearcut 100 ft from bank.																								
169	(1180; 1200; 1235; 1250; 1430/40) Possible connection to logging and landsliding.																								
170	*(1280) Bedrock exposed, not eroding significantly.*																								
171	(300-380; 400) Assumed sandy silt facies of outwash.																								
172	(1145) Bedrock on d/s end.																								
173	(1260) Alluvium overlying Tertiary siltstone.																								
174	(1190) Continuous with 1200.																								
175	(1070) Includes xs JY.																								

Table A-6: Riparian Vegetation and Land Use Inventory

Riparian land use and vegetation cover within 300 feet of the Deschutes River, as mapped from aerial photographs from 1941, 1953/4, 1965/6, 1972, 1981, and 1991. Codes used are:

Land Use Type	Code
Lawn	L
Industrial	I
Road	R
Pasture	P
Shrub	S
Riparian Buffer	B
Forest	F

Forest Composition	
Conifer Dominated (>70%)	C
Deciduous Dominated (>70%)	D
Mixed Forest	M

Forest Age	
Young (<40 years)	I
Mature (conifers: 40-120 years; deciduous or mixed: 40-80 years)	M
Old (conifers: >120 years; deciduous or mixed: >80 years)	O

Forest Density	
Sparse (>1/3 of ground exposed)	S
Dense (not sparse)	D

Right and left bank (RB and LB) are looking downstream. Lengths are given for RB and LB land use types closest to the river. If land use width is <300 ft, then the second- and third-closest land uses are also listed. If a width is not given, width is >300 ft, or is the difference between 300 ft and the widths of land uses closer to the river. An "x" indicates the land use codes are unchanged from the time interval to the left of the entry in the table. 1991 lengths are subtotaled for segments. Subtotals may not equal segment lengths because land use lengths that include two segments are included in the downstream segment.

RIPARIAN DATA

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1																										
2			1991				1981				1972				1965/66				1953				1941			
3	Bank	Seg	Length	Land	Desc	Width	Lengt	Land	Desc	Width	Lengt	Land	Desc	Width	Lengt	Land	Desc	Width	Lengt	Land	Desc	Width	Lengt	Land	Desc	Width
4			ft	Use		ft	ft	Use		ft	ft	Use		ft	ft	Use		ft	ft	Use		ft	ft	Use		ft
5																										
6	RB	1	325	L		50	x	x		x	x	x		x	x	x		150	x	B	DID	50	x	x	x	x
7	RB	1		I				x				x				x				I				x		
8	RB	1	100	R		100	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
9	RB	1		I				x				x				x				x				x		
10	RB	1	900	I			600	S		30	900	I			950	* I			400	* I			400	B	DMD	
11	RB	1						I											300	* R		50	300	x		x
12	RB	1					300	S		75										* I				S		
13	RB	1						I											500	* B	DID	150	500	B	DID	200
14	RB	1																		* I		50		R		50
15	RB	1																		* R		50				
16	RB	1																		* I						
17	RB	1	500	B	MMD	50	225	x	x	x	500	I			150	* S		100	x	x		x	750	B	DMD	200
18	RB	1		R		20		x		x						* R		50		x		x		R		20
19	RB	1		B	DID	100		x	x	x						* I				x			300	B	DMD	
20	RB	1		I				x							600	* B	DMD	150	x	x	x	x				
21	RB	1					275	B	MMD	50						* S		50		x		x				
22	RB	1						R		20						* R				x						
23	RB	1						I							300	* B	DMD		x	x	x					
24	RB	1	100	R		50	x	x		x	x	I			x	B	DMD		x	x	x		x	x	x	
25	RB	1		B	DIS	100		x	x	x																
26	RB	1		I				x																		
27	RB	1	850	B	DMD	50	x	B	DMD	20	x	L			200	B	DMD		x	x	x		x	x	x	
28	RB	1		P				x							350	P			x	x			x	x		
29	RB	1	500	B	DIS	30	x	x	x	x	x	L			200	B	DID	30	500	B	DID	75	x	x	x	x
30	RB	1		P				x								P				P				x		
31	RB	1													300	P										
32	RB	1	500	B	DID	30	250	B	DID	30	250	L			500	B	DMD		x	x	x		x	x	x	
33	RB	1		L		50		L																		
34	RB	1		R		20	250	L		50	x	x		x												
35	RB	1		L				R		20		x		x												
36	RB	1						L				x														
37			3575																							
38	LB	1	250	L			x	x			x	x			x	x			x	B	DMD		x	x	x	
39	LB	1	100	L		150	x	x		x	x	x		x	x	x		x	x	B	DMD		x	x	x	
40	LB	1		I				x				x				x										
41	LB	1	100	R		100	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
42	LB	1		I				x				x				x				x				x		
43	LB	1	750	S		150	x	x		x	x	x		x	x	x		x	x	B	DMD	150	x	x	x	x
44	LB	1		R				x				x				x				R				x		

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
45	LB	1	50	R			x	x			x	x			x	x			x	x			x	x		
46	LB	1	150	L		150	x	x		x	x	S		150	x	x		x	x	B	DMD	75	x	x	x	x
47	LB	1		R		50		x		x		x		x		x		x		P				x		
48	LB	1		S				x				x				x										
49	LB	1	700	B	MMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MMD	75	x	x	x	x
50	LB	1		L		50		x		x		x		x		S		50		P				x		
51	LB	1		R		50		x		x		x		x		R		50								
52	LB	1		S				x				x				S										
53	LB	1	250	B	DMD	100	x	x	x	x	x	S		100	x	S			x	B	DID	50	x	x	x	x
54	LB	1		R		50		x		x		x		x						S				x		
55	LB	1		L		50		S				S														
56	LB	1		I		50																				
57	LB	1		R		50																				
58	LB	1	150	R		100	x	S		30	x	x		x	x	S			x	P			x	B	DMD	75
59	LB	1		L		50		R		100		x		x										S		
60	LB	1		I		50		S				x														
61	LB	1		R		100																				
62	LB	1	300	I		100	x	x		x	x	x		x	x	P			x	x			x	B	DMD	50
63	LB	1		B	MIS	50		x	x	x		P												P		
64	LB	1		I		100		L		100																
65	LB	1		F	MMD			x	x																	
66	LB	1	250	B	CID	50	x	x	x	x	x	I		150	x	P			x	x			x	B	DMD	50
67	LB	1		I		200		x		x		P		75										P		
68	LB	1	350	B	DID	20	x	x	x	x	x	I			x	P			x	x			x	B	DMD	50
69	LB	1		I				x																P		
70			3400																							
71	RB	2	500	L		250	x	L			x	L		250	x	B	DMD		x	x	x		x	x	x	
72	RB	2		I								I														
73	RB	2	200	B	DID	20	x	L			x	L		225	x	B	DMD		x	x	x		x	x	x	
74	RB	2		L		200						I														
75	RB	2		I																						
76	RB	2	200	L		150	x	L		225	x	L		150	x	B	DMD	225	x	x	x	x	x	x	x	x
77	RB	2		I		75		R				I		75		R				x				x		
78	RB	2		R								R														
79	RB	2	300	L		200	x	x		x	x	x		x	x	B	DMD	200	x	x	x	x	x	x	x	x
80	RB	2		R		75		x		x		x		x		R		75		x		x		x		x
81	RB	2		F	OMD			x	x			x	x			F	OMD			x	x			x	x	
82	RB	2	250	L			x	x			x	x			x	B	DID		x	x	x		x	B	DIS	
83	RB	2	800	B	DID	50	x	x	x	x	x	L			x	B	DMD	100	500	B	DMD		x	x	x	
84	RB	2		L				x								P			300	B	DMD	150	x	x	x	x
85	RB	2																		P				x		
86	RB	2	350	B	DID	50	x	x	x	x	x	L		250	x	P		250	x	x		x	x	x		x
87	RB	2		L		200		x		x		R				R				x				x		
88	RB	2		R				x																		

RIPARIAN DATA

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
89	RB	2	200	B	DIS	50	x	x	x	x	x	L		250	100	B	DMD	50	x	x	x	x	x	x	x	x
90	RB	2		L		200		x		x		R				P		200		x		x		x		x
91	RB	2		R				x								R				x				x		
92	RB	2													100	P		250	x	x		x	x	x		x
93	RB	2														R				x				x		
94	RB	2	550	B	DID	50	x	L			x	x			200	B	DMD	100	x	x	x	x	x	x	x	x
95	RB	2		L												P				x				x		
96	RB	2													250	P		250	x	x		x	x	x		x
97	RB	2														R				x				x		
98	RB	2	500	B	DMD	50	x	x	x	x	x	L			x	P			x	x			x	x		
99	RB	2		L				x																		
100	RB	2	700	L			x	x			x	x			x	P			x	x			x	S		
101	RB	2	500	B	DID	50	x	L			x	x			x	P			x	x			x	x		
102	RB	2		L																						
103	RB	2	1100	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
104	RB	2	500	B	MID	200	x	x	x	x	x	x	x	x	x	P		x	x	x		x	x	x		x
105	RB	2		P				x				x														
106	RB	2	1475	F	MID		x	x	x		x	x	x		x	B	DID	100	1175	x	x	x	1475	P		x
107	RB	2														P				P						
108	RB	2																	300	P						
109	RB	2	350	B	MID	100	x	x	x	x	x	P			x	x			x	B	DMD	100	x	x		x
110	RB	2		S				P												P				x		x
111			8475																							
112	LB	2	600	L			x	x			x	x			x	P			x	B	DID	30	x	B	DID	100
113	LB	2																		P				P		
114	LB	2	350	B	DID	50	x	x	x	x	x	L			x	B	DMD		x	x	x		x	x	x	
115	LB	2		L				x																		
116	LB	2	200	B	DID	50	x	x	x	x	x	L		50	x	B	DMD		x	x	x		x	x	x	
117	LB	2		B	DMD	200		x	x	x		x	x	x												
118	LB	2		L				x				x														
119	LB	2	1700	B	DID	50	x	x	x	x	x	L			x	F	MMD		x	F	MMS		x	x	x	
120	LB	2		L				x																		
121	LB	2	150	B	DID	50	x	x	x	x	x	L			x	P			x	x			x	x		
122	LB	2		L				x																		
123	LB	2	700	B	DID	50	x	x	x	x	x	L			400	P			x	x			x	x		
124	LB	2		L				x							300	B	DMD	100	x	x	x	x	x	x	x	x
125	LB	2														P				x				x		
126	LB	2	200	B	DID	100	x	x	x	x	x	x	x	x	x	B	DMD	100	x	x	x	x	x	x	x	x
127	LB	2		L				x				x				P				x				x		
128	LB	2	1350	B	DID	50	x	x	x	x	x	L			x	B	DMD	150	x	x	x	x	x	x	x	x
129	LB	2		L				x								P				x				x		
130	LB	2	800	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
131	LB	2	350	B	MMD	200	x	x	x	x	x	x	x	x	250	F	DMD		x	x	x		x	x	x	
132	LB	2		L				x				x			100	P			x	x			x	x		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
133	LB	2	1600	F	MID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
134	LB	2	350	B	MIS	200	x	P			x	x			x	x			x	x			x	x		
135	LB	2		P																						
136	LB	2	250	P			x	x			x	x			x	x			x	x			x	x		
137	LB	2	1350	B	MMS	100	500	B	MMS	100	1350	F	MID		x	x	x		x	x	x		x	x	x	
138	LB	2		F	MID			S																		
139	LB	2					850	S																		
140			9950																							
141	RB	3	500	B	MID	50	x	x	x	30	x	P			x	x			x	B	DID	75	x	x	x	x
142	RB	3		P				x												P				x		
143	RB	3	150	B	MMD	200	x	x	x	x	x	x	x	x	x	x	x	150	x	x	x	x	x	x	x	x
144	RB	3		L				x				x				P				x				x		
145	RB	3	250	P			x	x			x	B	DID	50	x	x	x	x	x	x	x	x	x	P		
146	RB	3										P				x				x						
147	RB	3	200	B	MMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MID	100	x	P		
148	RB	3		R		30		x		x		x		x		x		x		P						
149	RB	3		P				x				F	MID			x	x									
150	RB	3	800	F	DID	200	x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
151	RB	3	1800	B	MMD	30	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
152	RB	3		R				x		x		x		x		x		x		x		x		x		x
153	RB	3		F	MMD			x	x			x	x			x	x			x	x			x	x	
154	RB	3	1700	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		1300	x	x	
155	RB	3																					400	B	MMD	100
156	RB	3																						P		
157	RB	3	250	S			x	x			x	x			x	x			x	x			x	F	MMD	
158	RB	3	1200	F	CMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
159			6850																							
160	LB	3	825	B	DID	30	x	x	x	x	x	R		30	300	R		30								
161	LB	3		R		30		x		x		P				P										
162	LB	3		P				x							525	B	DMD	75	825	B	DMD	75	x	x	x	x
163	LB	3														P				P				x		
164	LB	3	2500	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
165	LB	3	100	P			x	x			x	x			x	x			x	x			x	x		
166	LB	3	1000	F	DID		x	x	x		500	B	DID	100	x	x	x	x	1000	P			x	x		
167	LB	3										P				x										
168	LB	3									500	P			x	x										
169	LB	3	960	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
170	LB	3	200	S		150	x	x		x	x	x		x	x	x		x	x	P			x	x		
171	LB	3		P				x				x				x										
172	LB	3	225	B	MMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
173	LB	3		P				x				x				x				x				x		
174	LB	3	1100	F	DMD		x	x			x	x			x	x			x	x			x	x		
175			6900																							
176	RB	4	850	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
177	RB	4	650	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
178	RB	4	1800	B	DID	100		x	x	x	x	x	I			700	P			1000	P			x	x	
179	RB	4		I					x							300	S			800	F	OMD		x	x	x
180	RB	4														500	I		100							
181	RB	4															P									
182	RB	4														300	I									
183	RB	4	300	B	MMD	200		x	x	x	x	x	P			x	F	OMD		x	x	x		x	x	x
184	RB	4		P					x																	
185	RB	4	150	F	MMD			x	x	x		x	x	x		x	x	x		x	x	x		x	x	x
186	RB	4	850	F	DID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
187	RB	4	900	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
188			5500																							
189	LB	4	650	S		150	x	P			x	x			x	B	DMD	150	x	x	x	x	x	x	x	x
190	LB	4		P												P				x				x		
191	LB	4	200	P		200	x	x		x	x	x		x	x	x		x	x	x		x	x	B	DMD	100
192	LB	4		F	MID			x	x			x	x			x	x			x	x			P		
193	LB	4	500	F	MIS		x	x	x		x	x	x		x	B	DMD	50	x	F	MMD		x	x	x	
194	LB	4														S										
195	LB	4	150	P			x	x			x	x			x	B	DMD	50	x	F	MMD		x	x	x	
196	LB	4														S										
197	LB	4	1350	F	MIS			x	x	x		x	S			x	F	MMS		x	F	MMD		x	x	x
198	LB	4	1225	B	MMD	100		300	P			x	x			1225	F	MMS		x	F	MMD		x	x	x
199	LB	4		P				925	B	MMD	100	x	x	x	x											
200	LB	4							P				x													
201	LB	4	850	F	DMD		x	x			x	x			x	x			x	x			x	x		
202	LB	4	900	B	MMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
203	LB	4		F	MIS			x	x			F	CID			x	x			x	x			S		
204			5826																							
205	RB	5	2100	F	DID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
206	RB	5	1000	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
207	RB	5	600	B	DID	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
208	RB	5		F	OMD			x	x			x	x			x	x			x	x			x	x	
209			3700																							
210	LB	5	725	B	OMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
211	LB	5		P				x				x				x				x				x		
212	LB	5	1000	P			x	x			x	x			x	x			x	x			x	x		
213	LB	5	560	B	OMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
214	LB	5		P				x				x				x				x				x		
215	LB	5	1350	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
216			3625																							
217	RB	6	1300	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
218	RB	6	300	B	OMD	250	x	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x	
219	RB	6		S																						
220	RB	6	1100	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
221			2700																							
222	LB	6	250	B	MMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
223	LB	6		P				x				x				x				x				x		
224	LB	6	950	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
225	LB	6	500	F	DID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
226	LB	6	750	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
227	LB	6	1550	P			x	x			x	x			x	x			x	x			x	x		
228			4000																							
229	RB	7	200	B	MMS	100	x	x	x	x	x	x	x	x	x	x	x	x	x	P			x	x		
230	RB	7			S			x				x				x										
231	RB	7	150	F	MMD		x	x	x		x	F	MMS		x	B	MMD	50	x	x	x	x	x	x	x	x
232	RB	7														S				P				x		
233	RB	7	750	F	DID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
234			1100																							
235	LB	7	1000	B	DMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	F	MMD		x	x	x	
236	LB	7			P			x				x				x										
237			1000																							
238	RB	8	700	F	CID		350	x	x																	
239	RB	8					350	B	CID	100	700	F	CID		x	x	x		x	F	CIS		x	B	CIS	50
240	RB	8						P																S		
241	RB	8	700	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
242	RB	8		P				x				x				x				x				x		
243	RB	8	400	P			x	x			x	x			x	x			x	x			x	x		
244	RB	8	725	B	DID	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
245	RB	8		F	CMD			x	x			x	x			x	x			x	x			x	x	
246			2525																							
247	LB	8	300	B	DMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
248	LB	8		R		30		x		x		x		x		x		x		x		x		x		x
249	LB	8		P				x				x				x				x				x		
250	LB	8	175	P			x	x			x	x			x	x			x	x			x	x		
251	LB	8	300	B	DMD	150	x	S		75	x	R		30	x	x		x	x	P		150	x	x		x
252	LB	8		P				F	MMD			x	x			S		50		F	MMD			x	x	
253	LB	8														F	MMD									
254			775																							
255	RB	9	700	B	MMS	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
256	RB	9		P		150		x		x		x		x		x		x		x		x		x		x
257	RB	9		F	CMD			x	x			x	x			x	x			x	x			x	x	
258			700																							
259	LB	9	900	B	DMD	150	x	F	MMD		x	R		50	x	x		x	x	P		150	x	x		x
260	LB	9		I								F	MMD			x	x			F	MMD			x	x	
261	LB	9	700	B	DID	50	x	x	x	x	x	x	x	x	x	x	x	x	x	F	CID		x	x	x	
262	LB	9		I				x				x				x										
263	LB	9	400	P			x	x			x	x			x	x			x	x			x	x		
264			2000																							

RIPARIAN DATA

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
265	RB	10	2850	F	OMD		x	x	x		2550	x	x													
266	RB	10									300	B	OMD	100	2850	F	OMD		x	x	x		x	x	x	
267	RB	10										S														
268	RB	10	500	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
269	RB	10		P				x				x				x				x				x		
270	RB	10	500	P		200	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
271	RB	10		F	MMD			x	x			x	x			x	x			x	x			x	x	
272			3850																							
273	LB	10	1600	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
274	LB	10		P				x				x				x				x				x		
275	LB	10	300	P			x	x			x	x			x	x			x	x			x	x		
276	LB	10	550	F	MMS		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
277	LB	10	600	P		150	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
278	LB	10		R		50		x		x		x		x		x		x		x		x		x		x
279	LB	10		S		50		B	MMS	x		x	x	x		x	x	x		x	x	x		x	x	x
280	LB	10		I				x				P				x				x				x		
281			3050																							
282	RB	11	500	B	DID	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
283	RB	11		P				x				x				x				x				x		
284	RB	11	850	P			x	x			x	x			x	x			x	x			x	x		
285	RB	11	225	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
286	RB	11		R		20		x		x		x		x		x		x		x		x		x		x
287	RB	11		P				x				x				x				x				x		
288	RB	11	325	P		200	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
289	RB	11		R		30		x		x		x		x		x		x		x		x		x		x
290	RB	11		P				x				x				x				x				x		
291			1900																							
292	LB	11	200	B	DID	50	x	x	x	x	x	S		x	x	x		x	x	x		x	x	x		x
293	LB	11		I				x				P				x				x				x		
294	LB	11	500	P			x	x			x	x			x	x			x	x			x	x		
295			700																							
296	RB	12	1950	F	CID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
297			1950																							
298	LB	12	750	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
299	LB	12		P				x				x				x				x				x		
300	LB	12	325	B	DMS	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
301	LB	12		P		100		x		x		x		x		x		x		x		x		x		x
302	LB	12		B	DMS			x	x			x	x			x	x			x	x			x	x	
303	LB	12	175	P			x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
304	LB	12	1000	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
305	LB	12	500	B	OMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
306	LB	12		R				x				x				x				x				x		
307	LB	12	600	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
308	LB	12		L		125		x		x		x		x		x		x		x		x		x		x

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
309	LB	12		R		30		x		x		x		x		x		x		x		x		x		x
310			3350																							
311	RB	13	300	B	DMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
312	RB	13		P				x				x				x				x				x		
313	RB	13	1350	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
314	RB	13	600	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
315	RB	13		P				x				x				x				x				x		
316	RB	13	825	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
317	RB	13	100	R			x	x			x	x			x	x			x	x			x	x		
318			3175																							
319	LB	13	275	P		50	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
320	LB	13		B	DMD	150		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x
321	LB	13		I				x				x				x				x				x		
322	LB	13	500	B	DID	30	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
323	LB	13		P		100		x		x		x		x		x		x		x		x		x		x
324	LB	13		B	DMD	100		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x
325	LB	13		R		20		x		x		x		x		x		x		x		x		x		x
326	LB	13		I				x				x				x				x				x		
327	LB	13	550	B	DMD	175	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
328	LB	13		R		20		x		x		x		x		x		x		x		x		x		x
329	LB	13		I				x				x				x				x				x		
330	LB	13	400	B	DMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
331	LB	13		P				x				x				x				x				x		
332	LB	13	950	B	DMD	100	x	B	DMD	50	650	x	x	x	x	x	x	x	350	x	x	x	x	x	x	x
333	LB	13		P				x				x				x				x				x		
334	LB	13									300	P			x	x	x	x	600	x			x	x		
335	LB	13	100	R			x	x			x	x			x	x			x	x			x	x		
336			2775																							
337	RB	14	150	B	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
338	RB	14	125	P		175	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
339	RB	14		B	DMD	50		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x
340	RB	14		P				x				x				x				x				x		
341	RB	14	900	B	DMD	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
342	RB	14		P				x				x				x				x				x		
343	RB	14	1550	B	MMD	175	x	x	x	x	x	x	x	x	x	x	x	x	x	F	CID		x	x		
344	RB	14		P				x				x				x										
345			2725																							
346	LB	14	1500	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
347			1500																							
348	RB	15	1000	B	DID	150	x	x	x	x	600	x	x	x	x	x	x	x	400	x	x	x	x	x	x	x
349	RB	15		F	CID			x	x			x	x			x	x			x	x			x	x	
350	RB	15									300	P		200	x	x		x	600	x		x	x	x		x
351	RB	15										F	CID			x	x			x	x			x	x	
352			1000																							

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
353	LB	15	900	B	OMD	150	x	x	x	x	x	B	CID	150	x	x	x	x	x	x	x	x	x	B	CID	75
354	LB	15		R		100		x		x		R		100		x		x		x		x		S		75
355	LB	15		F	OMD			x	x			F	CID			x	x			x	x			R		100
356	LB	15																						P		
357	LB	15	500	F	MMS		x	x	x		350	x	x		x	x	x		500	F	CID		x	B	CID	75
358	LB	15									150	P			x	x								S		
359			1400																							
360	RB	16	650	B	DID	150	350	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
361	RB	16		F	CIS			x	x			x	x			x	x			x	x			x	x	
362	RB	16					300	P		150	x	x		x	x	x		x	x	x		x	x	x		x
363	RB	16						F	CIS			x	x			x	x			x	x			x	x	
364	RB	16	500	F	DID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
365	RB	16	1250	B	DID	30	x	x	x	x	800	x	x	x	x	x	x	x	x	x	x	x	1250	B	DMD	50
366	RB	16		P				x				x				x				x				P		
367	RB	16									450	P			x	x			x	x						
368	RB	16	175	P			x	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
369	RB	16						P				x				x				x				x		
370			2575																							
371	LB	16	800	B	DMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
372	LB	16		P				x				x				x				x				x		
373	LB	16	1000	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
374	LB	16		P				x				F	CID			x	x			x	x			S		
375	LB	16	250	F	CID		x	x	x		x	x	x		x	x	x		x	F	CIS		x	S		
376	LB	16	950	B	DID	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
377	LB	16		P				x				x				x				x				x		
378			3000																							
379	RB	17	1500	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
380	RB	17	650	B	DMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
381	RB	17		P				x				x				x				x				x		
382	RB	17	325	B	DMD	275	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
383	RB	17		P				x				x				x				x				x		
384	RB	17	1000	B	DMD	225	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
385	RB	17		P				x				x				x				x				x		
386	RB	17	1450	B	DMD		x	x	x		1150	x	x		x	x	x		x	x	x		x	x	x	
387	RB	17									300	P			x	x			x	x			x	x		
388	RB	17	650	B	DID	30	x	x	x	x	450	x	x	x	650	B	DID	30	x	x	x	x	x	x	x	x
389	RB	17		P				x				x				P				x				x		
390	RB	17									200	P														
391	RB	17	150	B	DMS		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
392	RB	17	1500	B	DMD	125	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
393	RB	17		P				x				x				x				x				x		
394			7225																							
395	LB	17	250	F	MID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
396	LB	17	300	B	DID	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
397	LB	17		P				x				x				x				x				x		
398	LB	17	175	F	OMS		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
399	LB	17	700	B	DID	75	300	x	x	x	x	x	x	x	x	x	x	x	700	B	DID	100	400	x	x	x
400	LB	17		P				x				x				x				P				x		
401	LB	17					400	P			x	x			x	x							200	P		
402	LB	17	250	P			x	x			x	x			x	x			x	B	DID	100	x	x	x	x
403	LB	17																		P				x		
404	LB	17	800	B	DMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
405	LB	17		P				x				x				x				x				x		
406	LB	17	400	R		20	x	x		x	x	B	DMD	75	x	x	x	x	x	x	x	x	x	x	x	x
407	LB	17		P				x				P				x				x				x		
408	LB	17	800	B	DID	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
409	LB	17		P		200		x		x		x		x		x		x		x		x		x		x
410	LB	17		R		20		x		x		x		x		x		x		x		x		x		x
411	LB	17		P				x				x				x				x				x		
412	LB	17	450	B	DMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
413	LB	17		P				x				x				x				x				x		
414	LB	17	300	B	DID	30	x	P		150	x	x		x	x	x		x	x	F	OMD		x	x	x	
415	LB	17		P		100		F	CID			x	x			x	x									
416	LB	17		F	CID																					
417	LB	17	700	F	CID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
418	LB	17	1200	S		150	x	x		x	x	x		x	x	x		x	x	F	DMD		x	x	x	
419	LB	17		F	OMD			x	x			x	x			x	x									
420	LB	17	500	F	OMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
421	LB	17		P				x				x				x				x				x		
422			6825																							
423	RB	18	975	B	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
424	RB	18	300	S		75	x	P			x	B	DID	50	x	x	x	x	x	x	x	x	x	x	x	x
425	RB	18		P								P				x				x				x		
426	RB	18	350	B	MID	250	x	x	x	x	x	x	x	x	x	B	MID	100	x	P			x	x		
427	RB	18		P				x				x				x										
428	RB	18	250	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
429	RB	18		P				x				x				x				x				x		
430	RB	18	525	B	MMS		x	x	x		x	x	MID		x	x	x		225	x	x		x	x	x	
431	RB	18																	300	P			x	x		
432	RB	18	300	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
433	RB	18		P				x				x				x				x				x		
434	RB	18	100	P			x	x			x	x			x	x			x	x			x	x		
435			2800																							
436	LB	18	400	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
437	LB	18	400	B	MMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
438	LB	18		P				x				x				x				x				x		
439	LB	18	600	B	DIS	30	x	x	x	x	x	P			x	x			x	x			300	P		
440	LB	18		P				x															300	B	DIS	30

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
441	LB	18																						P		
442	LB	18	500	B	DMD	125	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
443	LB	18		P				x				x				x				x				x		
444	LB	18	400	P			x	B	DID	30	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
445	LB	18						P				x				x				x				x		
446	LB	18	500	B	DMS	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
447	LB	18		P				x				x				x				x				x		
448	LB	18	1100	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
449	LB	18	250	B	MMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
450	LB	18		P				x				x				x				x				x		
451	LB	18	400	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
452	LB	18	550	L			x	x			x	B	MMD	100	250	x	x	x	550	B	MMD	100	x	F	OMD	
453	LB	18										P				x				S						
454	LB	18													300	P										
455			5100																							
456	RB	19	2900	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
457	RB	19	700	F	OMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
458	RB	19		R		20		x		x		x		x		x		x		x		x		x		x
459	RB	19		P				x				x				x				x				x		
460	RB	19	400	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
461	RB	19		R		20		x		x		x		x		x		x		x		x		x		x
462	RB	19		P				x				x				x				x				x		
463	RB	19	175	P			x	x			x	x			x	x			x	x			x	x		
464	RB	19	750	B	DID	125	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
465	RB	19		P				x				x				x				x				x		
466	RB	19	1350	B	MMD	75	x	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x	
467	RB	19		S																						
468			6275																							
469	LB	19	800	L		225	x	x		x	x	F	MMS		x	x	x		x	x	x		x	x	x	
470	LB	19		R		30		x		x																
471	LB	19		L				x																		
472	LB	19	300	B	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
473	LB	19	200	B	MMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
474	LB	19		P				x				x				x				x				x		
475	LB	19	125	P		225	x	x		x	x	P			x	x			x	x			x	x		
476	LB	19		R		30		x		x																
477	LB	19		B	CID			x	x																	
478	LB	19	650	L		150	x	x		x	x	P			x	x			x	x			x	x		
479	LB	19		R		30		x		x																
480	LB	19		L				x																		
481	LB	19	700	B	DMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	F	OMD	
482	LB	19		L				x				P				S				x						
483	LB	19	350	B	DMS	50	x	B	DMS	30	x	B	DMS	50	x	x	x	x	x	x	x	x	x	F	OMD	
484	LB	19		L		100		x		x		S				x				x						

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
485	LB	19		R		30		x		x																
486	LB	19		L				x																		
487	LB	19	200	L		150	x	P		150	x	B	DIS	30	x	x	x	x	x	B	DIS	30	x	B	MMD	100
488	LB	19		R		30		R		30		P				x				S		50		P		
489	LB	19		L				P												P						
490	LB	19	2250	F	MMS	200	x	x	x	x	x	x	x	x	x	x	x	x	x	F	MIS		x	x	x	
491	LB	19		R		50		x		x		x		x		x		x								
492	LB	19		F	MMS			x	x			x	x			x	x									
493			5575																							
494	RB	20	750	B	DMS	75	x	B	MMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
495	RB	20		S		75		R		20		x		x		x		x		x		x		x		x
496	RB	20		R		20		F	OMD			x	x			x	x			x	x			x	x	
497	RB	20		S																						
498	RB	20	325	S		250	x	F	OMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
499	RB	20		R		20		x		x		x		x		x		x		x		x		x		x
500	RB	20		S				F	OMD			x	x			x	x			x	x			x	x	
501	RB	20	250	B	DMD	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
502	RB	20		R		20		x		x		x		x		x		x		x		x		x		x
503	RB	20		F	CID			x	x			x	x			x	x			x	x			x	x	
504	RB	20	325	F	CID	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
505	RB	20		R		20		x		x		x		x		x		x		x		x		x		x
506	RB	20		F	CID			x	x			x	x			x	x			x	x			x	x	
507	RB	20	350	B	DMD	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
508	RB	20		R		20		x		x		x		x		x		x		x		x		x		x
509	RB	20		B	DMD	75		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x
510	RB	20		P				x				x				x				x				x		
511	RB	20	750	B	DID	30	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
512	RB	20		R		20		x		x		x		x		x		x		x		x		x		x
513	RB	20		F	MMD			x	x			x	x			x	x			x	x			x	x	
514	RB	20	800	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
515	RB	20		R		75		x		x		x		x		x		x		x		x		x		x
516	RB	20		B	OMD			x	x			x	x			x	x			x	x			x	x	
517			3550																							
518	LB	20	325	F	MIS		x	x	x		x	x	x		x	B	DMS	50	x	x	x	x	x	F	OMD	
519	LB	20														S				x						
520	LB	20	1000	B	DMD	150	x	x	x	x	x	x	x	x	x	B	DMS	100	x	x	x	x	x	F	MMD	
521	LB	20		F	CIS			x	x			x	x			S				x						
522	LB	20	800	F	DID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
523	LB	20	850	B	DID	150	x	x	x	x	x	x	x	x	x	x	x	x	600	x	x	x	x	x	x	x
524	LB	20		P				x				x				x				x				x		
525	LB	20																	250	P			x	x		
526			2975																							
527	RB	21	1800	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
528	RB	21	650	B	MMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
529	RB	21		P				x				x				x				x				x		
530	RB	21	500	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
531	RB	21		P				x				F	CID			x	x			x	x			x	x	
532			2950																							
533	LB	21	300	P			x	x			x	B	MMS	150	x	x	x	x	x	x	x	x	x	x	x	x
534	LB	21										P				x				x				x		
535	LB	21	1200	F	DMD		x	x	x		500	P*			x	x			x	x			x	x		
536	LB	21	475	B	MMS	125	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
537	LB	21		P				x				x				x				x				x		
538	LB	21	250	P		200	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
539	LB	21		R		30		x		x		x		x		x		x		x		x		x		x
540	LB	21		P				x				x				x				x				x		
541	LB	21	550	B	DMD	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
542	LB	21		P				x				x				x				x				x		
543			2775																							
544	RB	22	200	B	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
545	RB	22	650	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
546	RB	22		P				x				F	CID			x	x			x	x			x	x	
547	RB	22	900	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
548	RB	22	650	B	DMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
549	RB	22		P				x				x				x				x				x		
550	RB	22	400	B	DMD	100	x	x	x	x	x	F	MMS		x	x	x		x	B	MMS	125	x	x	x	x
551	RB	22		P				x												P				x		
552	RB	22	2750	F	CID		x	x	x		x	x	x		x	x	x		x	B	CID	200	x	B	CID	100
553	RB	22																		P				P		
554			5550																							
555	LB	22	800	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
556	LB	22	450	P			x	x			x	x			x	x			x	B	DMD	50	x	x	x	x
557	LB	22																		P				x		
558	LB	22	175	B	DID	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
559	LB	22		P				x				x				x				x				x		
560	LB	22	4000	F	CMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
561			5425																							
562	RB	23	1325	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	575	B	DMD	150
563	RB	23		P				x				x				x				x				P		
564	RB	23																					750	P		
565	RB	23	550	F	MIS		x	B	MIS	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
566	RB	23						P				x				x				x				x		
567	RB	23	1050	B	MMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
568	RB	23		F	MIS			P				x				x				x				x		
569	RB	23	1400	F	MMS		x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
570	RB	23	1100	F	MMS		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
571	RB	23	900	B	MMD	150	x	F	MMD		x	x	x		x	F	MMS		x	x	x		x	F	MIS	
572	RB	23		S																						

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
573	RB	23	650	B	MMD	200	x	F	MMD		x	x	x		x	F	MMS		x	x	x		x	F	MIS	
574	RB	23		S																						
575	RB	23	600	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
576	RB	23	975	B	MMD	200	x	F	MMD		x	F	MID		x	x	x		x	F	MIS		x	x	x	
577	RB	23		F	CMS																					
578	RB	23	950	B	MMD	150	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
579	RB	23		F	CMS																					
580	RB	23	750	B	MMD	150	x	F	MMD		x	F	MID		x	x	x		x	x	x		x	x	x	
581	RB	23		S																						
582	RB	23	350	F	CMS		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
583	RB	23	450	B	MMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
584	RB	23		P				x				x				x				x				x		
585	RB	23	1550	F	CMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
586	RB	23	9200	B	MMD	50	6200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
587	RB	23		P				x																		
588			21800				3000	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
589	LB	23	250	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
590	LB	23		P		50		x		x		x		x		x		x		x		x		x		x
591	LB	23		R		100		x		x		x		x		x		x		x		x		x		x
592	LB	23		F	MMS			x	x			x	x			x	x			x	x			x	x	
593	LB	23	200	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	P		
594	LB	23		P				x				x				x				x						
595	LB	23	200	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	P		
596	LB	23		P		100		x		x		x		x		x		x		x		x				
597	LB	23		R		50		x		x		x		x		x		x		x		x				
598	LB	23		F	CIS			x	x			x	x			x	x			x	x					
599	LB	23	200	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
600	LB	23		P				x				x				x				x				x		
601	LB	23	650	P			x	x			x	x			x	x			x	F	CMD		x	x	x	
602	LB	23	800	B	DMS	150	x	x	x	x	x	x	x	x	x	x	x	x	x	F	CMD			x	x	x
603	LB	23		P				x				x				x										
604	LB	23	1500	B	MMD	100	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
605	LB	23		S																						
606	LB	23	550	B	MMD	100	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
607	LB	23		R		30																				
608	LB	23		S																						
609	LB	23	6050	B	MMD	100	x	F	MID		x	x	x		x	x	x		x	x	x		x	S		
610	LB	23		S																						
611	LB	23	850	B	MMD	100	x	F	MID		x	x	x		x	x	x		x	x	x		x	S		
612	LB	23		R		20																				
613	LB	23		S																						
614	LB	23	2300	B	MMD	100	x	F	MID		x	x	x		x	x	x		x	x	x		x	S		
615	LB	23		S																						
616	LB	23	1250	B	MMD	150	1000	x	x	x	1250	F	CID		x	x	x		x	x	x		x	B	MMD	50

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
617	LB	23		S				x																S		
618	LB	23					250	F	CMD																	
619	LB	23	1050	B	MMD	50	x	F	MMD		x	F	MID		x	x	x		x	x	x		x	x	x	
620	LB	23		S		150																				
621	LB	23		B	MMD																					
622	LB	23	300	B	MMD	50	x	F	CMD		x	x	x		x	x	x		x	F	CID		x	x	x	
623	LB	23		S																						
624	LB	23	700	B	MMD	50	x	F	CMD		x	x	x		x	x	x		x	F	CID		x	x	x	
625	LB	23		S		100																				
626	LB	23		B	CMD																					
627	LB	23	300	F	CMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
628	LB	23	1050	B	MMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
629	LB	23		P		100		x		x		x		x		x		x		x		x		x		x
630	LB	23		R		30		x		x		x		x		x		x		x		x		x		x
631	LB	23		P				x				x				x				x				x		
632			18200																							
633	RB	24	1500	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
634	RB	24	1200	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
635	RB	24		P				x				x				x				x				x		
636	RB	24	1400	B	MMS	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
637	RB	24		P				x				x				x				x				x		
638			4100																							
639	LB	24	750	B	MMS	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
640	LB	24		R		50		x		x		x		x		x		x		x		x		x		x
641	LB	24		P				F	CMD			x	x			x	x			x	x			x	x	
642	LB	24	2500	F	CMS		x	x	x		x	F	CMD		x	x	x		x	x	x		x	x	x	
643	LB	24	275	B	MMD	150	x	F	CMS		x	F	CMD		x	x	x		x	x	x		x	x	x	
644	LB	24		R		150																				
645	LB	24	1050	F	CMS		x	x	x		x	F	CMD		x	x	x		x	x	x		x	x	x	
646	LB	24	1000	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
647	LB	24	1000	P			x	x			x	x			x	x			500	P			1000	B	DMD	50
648	LB	24																	500	B	DMD	50		P		
649	LB	24																		P						
650	LB	24	1100	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
651			7675																							
652	RB	25	700	B	DIS	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
653	RB	25		P				x				x				x				x				x		
654	RB	25	400	P		200	x	x		x	x	x		x	100	B	MMD	100	400	B	MMD	100	x	x	x	x
655	RB	25		F	CID			x	x			x	x			P				F	CID			x	x	
656	RB	25													300	P		200								
657	RB	25														F	CID									
658	RB	25	500	B	DMD	100	x	x	x	x	x	x	x	x	x	F	DID		x	x	x		x	x	x	
659	RB	25		P		100		x		x		x		x												
660	RB	25		F	CID			x	x			x	x													

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
661	RB	25	900	F	OMD		x	x	x		x	B	OMD	250	x	x	x	x	x	x	x	x	x	x	x	x
662	RB	25										S				F	CID			x	x			S		
663	RB	25	600	B	MID	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
664	RB	25		F	MMD			x	x			x	x			x	x			x	x			x	x	
665	RB	25	400	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
666			3500																							
667	LB	25	350	B	OMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
668	LB	25		R		50		x		x		x		x		x		x		x		x		x		x
669	LB	25		P				x				x				x				x				x		
670	LB	25	1000	B	DMD	150	x	x	x	x	x	x	x	x	x	B	DMD	150	x	x	x	x	x	x	x	x
671	LB	25		P		50		x		x		x		x		P				x				x		
672	LB	25		R		20		x		x		x		x												
673	LB	25		P				x				x														
674	LB	25	750	F	MMD		x	F	MID		x	x	x		x	x	x		x	x	x		x	B	MMD	175
675	LB	25																						S		
676	LB	25	500	F	MMS		x	x	x		x	x	x		x	F	MMD		x	x	x		x	x	x	
677	LB	25	450	B	MMD	120	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
678	LB	25		R		50		x		x		x		x		x		x		x		x		x		x
679	LB	25		F	MID			x	x			x	x			x	x			x	x			x	x	
680	LB	25	300	B	MMD	200	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
681	LB	25		S																						
682	LB	25	800	B	MMD		x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
683	LB	25	300	B	MMD	150	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
684	LB	25		S																						
685	LB	25	1050	B	MMD	100	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
686	LB	25		S																						
687	LB	25	725	B	DMD	.150	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
688	LB	25		S																						
689			6225																							
690	RB	26	5150	B	MMD	75	x	F	MMD		x	B	MMD	150	x	x	x	x	x	x	x	x	x	x	x	x
691	RB	26		S								F	MID			x	x			F	MIS			S		
692	RB	26	650	B	MMD	75	x	F	MMD		x	F	MID		x	x	x		x	x	x		x	B	MMD	150
693	RB	26		S		100																		S		
694	RB	26		B	OMD																					
695	RB	26	1350	B	OMD	100	x	F	MMD		x	F	MID		x	x	x		x	x	x		x	x	x	
696	RB	26		S																						
697			7150																							
698	LB	26	400	B	OMD	200	x	x	x	x	x	x	x	x	x	F	OMD		x	x	x		x	x	x	
699	LB	26		R		50		x		x		x		x												
700	LB	26		F	OMD			x	x			x	x													
701	LB	26	450	B	MMD	50	x	x	x	x	x	B	OMD	100	x	F	OMD		x	x	x		x	x	x	
702	LB	26		B	MID	50		S		50		R		50												
703	LB	26		R		50		x		x		F	OMD													
704	LB	26		F	MID			S																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
705	LB	26	1050	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
706	LB	26	450	B	MMD	125	x	x	x	x	x	x	x	x	x	F	MMD		x	x	x		x	x	x	
707	LB	26		R		50		x		x		x		x												
708	LB	26		F	MID			S				F	OMMD													
709	LB	26	900	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
710	LB	26	800	B	MMD	100	x	x	x	x	x	x	x	x	x	F	MMD		x	x	x		x	x	x	
711	LB	26		R		50		x		x		x		x												
712	LB	26		B	OMD			x	x			x	x													
713	LB	26	400	B	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
714	LB	26	325	B	OMD	100	x	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x	
715	LB	26		S																						
716	LB	26	550	F	OMD		x	x	x		x	x	x		x	x	x		x	F	CID		x	x	x	
717			5325																							
718	RB	27	1400	F	MMD	250	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
719	RB	27		R				x				x				x				x				x		
720	RB	27	1300	F	MMD		x	x	x		x	B	MMD	200	x	x	x	x	x	B	MMD	200	x	x	x	x
721	RB	27										F	CID			x	x			F	CIS			S		
722	RB	27	1000	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
723	RB	27	1200	F	MMD	200	x	x	x	x	x	F	MID	200	x	x	x	x	x	x	x	x	x	x	x	x
724	RB	27		R		50		x		x		R		50		x		x		x		x		x		x
725	RB	27		F	OMD			x	x			F	CID			x	x			x	x			x	x	
726	RB	27	3000	F	MMD		x	x	x		x	x	x		x	F	MID		x	F	MIS		x	x	x	
727	RB	27	600	B	MMD	100	x	x	x	x	x	B	MID	100	x	x	x	x	x	B	MIS	100	x	S		100
728	RB	27		R		50		x		x		R		50		x		x		x		x		x		x
729	RB	27		F	OMD			x	x			F	CID			x	x			F	CIS			x	x	
730	RB	27	350	S		225	x	x		x	225	S		75	x	x		x	x	x		x	x	x		x
731	RB	27		B	MIS	30		x	x	x		F	CID			x	x			x	x			x	x	
732	RB	27		R				x			75	S		225	x	x		x	x	x		x	x	x		x
733	RB	27										R		30		x		x		x		x		x		x
734	RB	27	400	S			x	x			x	x			x	x			x	x			x	x		
735	RB	27	1150	F	CID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
736	RB	27	1500	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
737	RB	27	150	F	OMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
738	RB	27		R		50		x		x		x		x		x		x		x		x		x		x
739	RB	27		F	OMD			x	x			x	x			x	x			x	x			x	x	
740	RB	27	850	B	MMD	50	x	x	x	x	x	F	MMD		x	x	x		x	x	x		x	x	x	
741	RB	27		P				x																		
742	RB	27	550	B	CID	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
743	RB	27		R		50		x		x		x		x		x		x		x		x		x		x
744	RB	27		F	OMD			x	x			x	x			x	x			x	x			x	x	
745			13450																							
746	LB	27	950	B	MMD	100	x	x	x	x	x	F	MMD		x	x	x		x	x	x		x	x	x	
747	LB	27		F	MID			S																		
748	LB	27	225	S			x	x			x	F	MMD		x	x	x		x	x	x		x	x	x	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
749	LB	27	525	B	OMD	200	x	x	x	x	x	F	CID		x	x	x		x	F	CIS		x	S		
750	LB	27		R				x																		
751	LB	27	1400	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		750	x	x	x
752	LB	27																					650	S		
753	LB	27	400	S		200	x	x		x	x	x		x	x*	F	MMD		x	x	x		x	x	x	
754	LB	27		F	OMD			x	x			x	x													
755	LB	27	2250	F	MMD		x	x	x		x	F	MID		x	x	x		x	x	x		1250	B	CIS	100
756	LB	27																						S		
757	LB	27																					1000	S		
758	LB	27	800	F	OOD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
759	LB	27	750	F	MMD	250	x	x	x	x	x	F	MID	250	x	x	x	x	x	F	MID		x	S		
760	LB	27		R				x				R		50		x		x								
761	LB	27	300	S			x	x			x	F	CID		x	x	x		x	x	x		x	x	x	
762	LB	27	300	S			x	x			x	x			x	x			x	x			x	x		
763	LB	27	1550	B	MMD	150	x	x	x	x	x	F	MID		x	x	x		x	x	x		x	x	x	
764	LB	27		F	CID			S																		
765	LB	27	1500	B	DMD	75	x	F	MMD		x	x	x		x	F	MID		x	F	MIS		x	B	MID	75
766	LB	27		S																				S		
767	LB	27	650	B	MMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MMD	150
768	LB	27		F	MID			x	x			x	x			x	x			x	x			S		
769			11600																							
770	RB	28	1300	F	OMD		x	x	x		x	x	x		x	x	x		x	F	CIS		900	x	x	
771	RB	28																					400	B	CIS	50
772	RB	28																						P		
773	RB	28	150	B	MMD	50	x	x	x	x	x	F	MID		x	x	x		x	P			x	x		
774	RB	28		P				x																		
775	RB	28	2900	F	OMD		x	x	x		x	x	x		1200	F	CIS		x	x	x		x	x	x	
776	RB	28													1700	F	CID		x	B	MIS	75	x	x	x	x
777	RB	28																		P				x		
778	RB	28	350	B	MMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MIS	50	x	B	MID	30
779	RB	28		L				x				P				x				I				P		
780	RB	28	500	B	MMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
781	RB	28		P				x				x				x				x				x		
782	RB	28	5100	F	OMD		2950	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
783	RB	28					2150	B	OMD	200	x	B	CID	200	x	x	x	x	x	F	CID		x	B	OMD	50
784	RB	28						R		30		x		x		x		x						S		
785	RB	28						F	OMD			F	CID			x	x									
786			10300																							
787	LB	28	1800	B	MMD	75	x	x	x	x	800	B	MID	75	x	B	MIS	75	800	F	MMS		x	x	x	
788	LB	28		F	OMS			x	x			S				P			300	F	OMS		x	x	x	
789	LB	28									1000	F	OMS		x	x	x		700	B	MMS	50	x	x	x	x
790	LB	28																		P				S		
791	LB	28	3100	F	OMD		x	x	x		x	F	CID		x	x	x		750	F	CIS		3100	B	MID	50
792	LB	28																	2350	B	MID	50		S		

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
793	LB	28																			S					
794	LB	28	750	B	OMD	100	x	x	x	x	x	F	CID		x	x	x		x	F	CIS		x	B	MID	50
795	LB	28		S				x																S		
796	LB	28	650	F	OMD		x	x	x		x	F	CID		x	x	x		x	F	CIS		x	B	MIS	50
797	LB	28																						S		
798	LB	28	1300	B	OMD	150	x	x	x	x	x	B	CID	150	x	F	CID		x	F	CIS		x	B	MIS	50
799	LB	28		R		50		x		x		x		x										S		
800	LB	28		F	OMD			x	x			F	CID													
801	LB	28	650	F	OMD		x	x	x		x	F	CID		x	x	x		x	F	CIS		x	F	OMD	
802	LB	28	450	B	OMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
803	LB	28		R		50		x		x		x		x		x		x		x		x		x		x
804	LB	28		F	OMD			x	x			x	x			x	x			x	x			x	x	
805			8700																							
806	RB	29	550	B	OMD	200	x	x	x	x	x	F	CID		x	x	x		x	x	x		x	B	CID	50
807	RB	29		F	CIS			x	x															S		
808	RB	29	750	B	OMD	100	x	x	x	x	x	B	CID	200	x	x	x	x	x	x	x	x	x	B	CID	75
809	RB	29		R		30		x		x		x		x		x		x		x		x		S		
810	RB	29		B	OMD	100		x	x	x		F	CID			x	x			x	x					
811	RB	29		F	CIS			x	x																	
812	RB	29	2200	B	MMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
813	RB	29		F	MIS			S				F	CID			x	x			S				x		
814	RB	29	1500	F	MMD		x	x	x		x	F	CID		x	F	CIS		x	B	MMD	50	x	x	x	x
815	RB	29																		S				x		
816	RB	29	750	B	MMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
817	RB	29		F	OMS			x	x			x	x			F	CIS			S				x		
818	RB	29	3750	F	MMD		x	x	x		x	x	x		x	x	x		2000	x	x		x	x	x	
819	RB	29																	1750	B	DMD	50	x	x	x	x
820	RB	29																		S				x		
821			9500																							
822	LB	29	1500	B	OMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MID	75
823	LB	29		R		20		x		x		x		x		x		x		F	CIS	75		S		100
824	LB	29		B	OMD	50		x	x	x		F	CID	x		x	x	x		R		50		R		50
825	LB	29		R		50		x		x		x		x		x		x		F	CIS			S		
826	LB	29		B	OMD			x	x			F	CID			F	CIS									
827	LB	29	850	B	MMD	200	x	x	x	x	x	x	x	x	x	B	MID	100	x	x	x	x	x	x	x	x
828	LB	29		R		30		x		x		x		x		F	CIS			x	x			S		
829	LB	29		F	OMD			x	x			x	x													
830	LB	29	1100	F	MMD		x	x	x		x	x	x		x	F	CID		x	F	CIS		x	B	MID	75
831	LB	29																						S		
832	LB	29	500	B	OMD	250	x	x	x	x	x	x	x	x	x	F	CID		x	B	MID	30	x	x	x	x
833	LB	29		R		50		x		x		x		x						S				x		
834	LB	29	900	B	MMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
835	LB	29		R		30		x		x		x		x		F	CID			F	CIS			S		
836	LB	29		F	OMS			x	x			x	x													

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
837	LB	29	350	B	MMD	150	x	x	x	x	x	F	MMS		x	F	MIS		x	x	x		x	B	MMD	75
838	LB	29		R		30		x		x														S		
839	LB	29		P				x																		
840	LB	•	1050	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
841	LB	29		P				x				x				x				x				S		
842	LB	29	650	F	OMD		x	F	CID		x	x	x		x	x	x		x	B	MID	75	x	x	x	x
843	LB	29																		S				x		
844	LB	29	1550	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	900	x	x	x	1550	B	MMD	50
845	LB	29		F	OMD			x	x			F	CID			x	x			x	x			S		
846	LB	29																	650	B	DMD	200				
847	LB	29																		S						
848	LB	29	500	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	B	DMD	50
849	LB	29		R		30		x		x		x		x		x		x		x		x		S		
850	LB	29		F	OMD			x	x			x	x			x	x			x	x					
851	LB	29	1050	B	DMD	75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
852	LB	29		P				x				x				x				x				x		
853	LB	29	1050	F	MMD		x	x	x		450	x	x		x	x	x		x	x	x		x	x	x	
854	LB	29									600	F	CIS		x	x	x		x	x	x		x	F	OMD	
855			11050																							
856	RB	30	1100	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	F	CID		x	x	x	
857	RB	30		P				x				x				x										
858	RB	30	1100	P			x	x			x	x			x	x			400	F	CID		x	x	x	
859	RB	30																	700	B	MID	100	x	x	x	x
860	RB	30																		P				x		
861	RB	30	600	B	DMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
862	RB	30		P				x				x				x				x				x		
863	RB	30	150	P			x	x			x	x			x	B	OMD	50	x	x	x	x	x	x	x	x
864	RB	30														P				x				x		
865	RB	30	3100	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
866	RB	30		P				x				x				x				x				x		
867	RB	30	2800	F	MMD		x	x	x		x	x	x		x	x	x		x	B	MMD	75	x	x	x	x
868	RB	30																		S				x		
869			8850																							
870	LB	30	250	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
871	LB	30		P				x				x				x				x				x		
872	LB	30	200	P			x	x			x	x			x	B	DID	50	x	F	CIS		x	x	X	
873	LB	30														P										
874	LB	30	300	B	DID	50	x	x	x	x	x	x	x	x	x	x	x	x	x	F	CIS		x	F	OMD	
875	LB	30		P				x				x				x										
876	LB	30	600	B	DMD	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
877	LB	30		P.				x				x				x				x				x		
878	LB	30	300	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
879	LB	30		P				x				x				x				x				x		
880	LB	30	300	P			x	x			x	B	DID	50	x	x	x	x	x	x	x	x	x	x	x	x

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
881	LB	30										P				x				x				x		
882	LB	30	1450	F	MMD		x	x	x		x	B	DMD	50	x	B	DMD	50	x	x	x	x	x	x	x	x
883	LB	30										F	CID			F	CID			F	CIS			S		
884	LB	30	400	B	MMD	150	x	F	MMD		x	F	MID		x	B	DMD	100	x	x	x	x	x	x	x	x
885	LB	30		P												F	CIS			x	x			S		
886	LB	30	2500	F	MMD		x	x	x		x	F	MID		x	x	x		x	F	CIS		1100	B	DID	30
887	LB	30																						S		
888	LB	30																					1400	F	CIS	
889	LB	30	1900	B	MMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
890	LB	30		R		30		x		x		x		x		x		x		x		x		x		x
891	LB	30		F	MIS			x	x			S				x				x				x		
892			8200																							
893	RB	31	1400	B	DMS	200	x	x	x	x	900	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
894	RB	31		P				x				x			x					x				x		
895	RB	31									500	P		x	x				x	x			x	x		
896	RB	31	450	P			x	x			x	x			x	x			x	x			x	x		
897	RB	31	2050	B	DMS	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
898	RB	31		P				x				x				x				x				x		
899	RB	31	450	R		30	x	x		x	x	x		x	x	B	DMS	50	x	x	x	x	x	x	x	x
900	RB	31		P				x				x				R		30		x		x		x		x
901	RB	31														P				x				x		
902	RB	31	2050	B	DMS	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
903	RB	31		P				x				x				x				x				x		
904	RB	31	1100	F	DMS		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
905			7500																							
906	LB	31	1350	B	DMS	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
907	LB	31		P				x				x				x				S				P		
908	LB	31	550	B	MMS	300	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
909	LB	31	400	P		100	x	x		x	x	x		x	x	x		x	x	x		x	x	B	MMD	100
910	LB	31		F	MMD			F	MID			x	x			x	x			x	x			P		
911	LB	31	450	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
912	LB	31	1000	F	MMS		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
913	LB	31	1250	B	OMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
914	LB	31		P				x				x				x				x				x		
915	LB	31	3400	F	MID		x	x	x		x	F	MIS		x	B	MIS	50	x	F	OMD		x	x	x	
916	LB	31														S										
917			8400																							
918	RB	32	750	P			x	x			x	x			x	x			x	B	DMD	50	x	x	x	x
919	RB	32																		P				x		
920	RB	32	1050	B	DMD	50	x	x	x	x	x	x	x	150	x	x	x	x	x	x	x	175	x	x	x	x
921	RB	32		L		100		x		x		R		30		x		x		P				x		
922	RB	32		R		30		x		x		L				P										
923	RB	32		P				x																		
924	RB	32	350	B	DID	50	x	x	x	x	x	P			x	x			x	x			x	x		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
925	RB	32		P				x																		
926	RB	32	1400	L		200	x	x		x	x	x		x	x	x		x	x	B	DMS	200	x	x	x	x
927	RB	32		R		50		x		x		x		x		x		x		P				x		
928	RB	32		P				x				x				x										
929	RB	32	375	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
930	RB	32		P				x				x				x				x				x		
931	RB	32	600	F	MMD		x	x	x		x	F	MMS		450	x	x		x	B	MMD	100	x	x	x	x
932	RB	32																		P				x		
933	RB	32	100	P			x	x			x	x	x		250	P			x	x			x	x		
934	RB	32	650	F	MID		x	x	x		x	F	MIS		x	P			x	x			x	x		
935	RB	32	1000	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
936	RB	32		R		50		x		x		x		x		x		x		x		x		x		x
937	RB	32		F	CIS			x	x			x	x			x	x			x	x			x	x	
938	RB	32	600	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
939	RB	32		P				x				x				x				x				x		
940	RB	32	350	B	DID	30	x	P		75	x	x		x	x	P			x	x			x	x		
941	RB	32		P		50		R		50		x		x												
942	RB	32		R		50		P				x														
943	RB	32		P																						
944			7225																							
945	LB	32	2150	L		150	x	x		x	x	x		x	x	x		x	x	F	CIS		x	F	OMD	
946	LB	32		R		30		x		x		x		x		x		x								
947	LB	32		P				x				x				x										
948	LB	32	550	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MMD	75	x	x	x	x
949	LB	32		L		150		x		x		x		x		x		x		P				x		
950	LB	32		R		30		x		x		x		x		x		x								
951	LB	32		P				x				x				x										
952	LB	32	700	B	MMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
953	LB	32		P				x				x				x				x				x		
954	LB	32	500	B	MMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
955	LB	32		P				x				x				x				x				x		
956	LB	32	150	P			x	x			x	x			x	x			x	x			x	x		
957	LB	32	400	B	MMS	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
958	LB	32		L		100		x		x		x		x		x		x		x		x		x		x
959	LB	32		R		30		x		x		x		x		x		x		x		x		x		x
960	LB	32		P				x				x				x				x				x		
961	LB	32	1800	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
962	LB	32	450	B	DID	50	x	P			x	x			x	x			x	x			x	B	MMD	100
963	LB	32		P																				P		
964			6700																							
965	RB	33	250	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
966	RB	33		P		50		x		x		x				x				x				x		
967	RB	33		R		50		x		x		x				x				x				x		
968	RB	33		P				x				x				x				x				x		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
969	RB	33	450	B	DMS	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
970	RB	33		P				x				x				x				x				x		
971	RB	33	500	P		150	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
972	RB	33		F	MMD			x	x			x	x			x	x			x	x			x	x	
973	RB	33	550	B	DID	50	x	x	x	x	x	x	x	x	x	x	x	x	x	P			x	x		
974	RB	33		P				x				x				x										
975	RB	33	1250	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	P		200	x	x		x
976	RB	33		L		50		x		x		x		x		x		x		R		20		x		x
977	RB	33		R		30		x		x		x		x		x		x		P				x		
978	RB	33		P				x				x				x										
979	RB	33	1650	B	DMS	250	x	x	x	x	x	x	x	x	x	x	x	x	x	F	CMS		x	x	x	
980	RB	33		R		30		x		x		x		x		x		x								
981	RB	33		B	MMD			x	x			x	x			x	x									
982			4650																							
983	LB	33	400	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
984	LB	33		P				x				x				x				x				x		
985	LB	33	500	P			x	x			x	x			x	x			x	x			x	x		
986	LB	33	300	B	DMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
987	LB	33		P				x				x				x				x				x		
988	LB	33	2750	B	DMD	150	x	x	x	x	2100	x	x	x	x	F	CMD		x	x	x		x	x	x	
989	LB	33		R		30		x		x		x		x												
990	LB	33		F	MMD			x	x			x	x													
991	LB	33									650	B	DID	50	x	x	x	x	x	x	x	x	x	x	x	x
992	LB	33										P				x				x				x		
993			3950																							
994	RB	34	1000	B	DID	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
995	RB	34		S				F	OMD			x	x			x	x			x	x			x	x	
996	RB	34	750	B	DMS	50	x	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x	
997	RB	34		S																						
998	RB	34	700	B	DMD	200	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
999	RB	34		S																						
1000	RB	34	350	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1001	RB	34	1150	B	DID	100	x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
1002	RB	34		S																						
1003	RB	34	275	R		100	x	x		x	400	P			x	x			x	x			x	x		
1004	RB	34		S				x																		
1005	RB	34	800	B	CMS	50	x	x	x	x	x	F	OMD	250	x	x	x	x	x	x	x	x	x	x	x	x
1006	RB	34		B	CID	100		S		100		R		30		x		x		x		x		x		x
1007	RB	34		R		30		x		x		F	OMD			x	x			x	x			x	x	
1008	RB	34		F	CID			S																		
1009			5025																							
1010	LB	34	1900	F	CID		x	x	x		x	F	CIS		1000	S			1900	F	OMD		x	x	x	
1011	LB	34													900	B	MMS	200								
1012	LB	34														S										

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1013	LB	34	450	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1014	LB	34	700	F	DID		x	x	x		x	x	x		x	B	DIS	50	x	F	MMD		x	x	x	
1015	LB	34														S										
1016	LB	34	550	F	DMD	275	x	x	x	x	x	F*	CIS	75	x	S		75	x	F	OMD		x	x	x	
1017	LB	34		R		20		x		x		R		20		x		x								
1018	LB	34										F	CIS			S		75								
1019	LB	34	500	B	DID	75	x	x	x	x	x	x	x	x	x	x	x	x	x	F	OMD		x	x	x	
1020	LB	34		F	CIS			x	x			S				x										
1021	LB	34	700	F	CID		x	x	x		x	F	CIS		x	S			x	F	OMD		x	x	x	
1022	LB	34	1000	B	DMD	275	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1023	LB	34		P				x				x				x				x				x		
1024	LB	34	250	P			x	x			x	x			x	x			x	x			x	x		
1025	LB	34	150	F	MID		x	x	x		x	x	x		x	P			x	x			x	x		
1026	LB	34	975	S			x	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x	
1027			7175																							
1028	RB	35	1200	B	DMD	75	1400	* F	DMD		x	x	x		x	x	x		x	x	x		x	x	x	
1029	RB	35		F	CID		500	B	DMD	75	x	F	OMD		x	x	x		x	x	x		x	x	x	
1030	RB	35						S																		
1031	RB	35	375	B	CID	150	x	x	x	x	x	x	x	x	x	x	x	x	x	S		150	x	F	OMD	
1032	RB	35		S				F	OMD			x	x			x	x			x	x					
1033	RB	35	300	F	CID		x	x	x		x	F	CIS		x	x	x		x	B	CIS	100	x	F	OMD	
1034	RB	35																		S						
1035	RB	35	800	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1036	RB	35	650	B	OMD	50	x	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x	
1037	RB	35		S																						
1038	RB	35	900	B	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1039	RB	35	500	B	OMD	200	x	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x	
1040	RB	35		S																						
1041	RB	35	250	B	OMD	225	x	x	x	x	x	F	OMD		x	x	x		x	x	x		x	x	x	
1042	RB	35		R		30		x		x																
1043	RB	35		S				F	OMD																	
1044	RB	35	150	B	MID	50	x	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x	
1045	RB	35		S																						
1046			5125																							
1047	LB	35	2000	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1048	LB	35	1500	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1049	LB	35	2050	F	CID		x	x	x		x	x	x		x	x	x		x	S			x	F	OMD	
1050			5550																							
1051	RB	36	1700	F	CID		x	x	x		800	B	CIS	200	x	x	x	x	1700	F	OMD		x	x	x	
1052	RB	36										S				x										
1053	RB	36									900	S			x	x										
1054	RB	36	1650	F	DID		x	x	x		x	x	x		x	x	x		1000	S			1650	F	OMD	
1055	RB	36																	650	B	DID	200				
1056	RB	36																		S						

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1057	RB	36	550	F	OMD		x	x	x		x	F	OMS		x	x	x		x	x	x		x	x	x	
1058	RB	36	1950	B	MMD	250	x	x	x	x	x	x	x	x	x	x	x	x	1375	B	DIS	200	x	x	x	x
1059	RB	36		F	OMD			F	CID			x	x			x	x			S				x		
1060	RB	36																	575	S			x	x		
1061			5850																							
1062	LB	36	1650	F	MMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1063	LB	36	500	F	CID		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1064	LB	36	2675	F	OMD		x	x	x		x	x	x		x	x	x		x	x	x		1675	x	x	
1065	LB	36																					1000	B	OMD	
1066	LB	36																						S		
1067			4825																							
1068	RB	37	500	F	CID	275	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1069	RB	37		R		20		x		x		x		x		x		x		x		x		x		x
1070	RB	37	2150	F	CIS	200	x	x	x	x	650	F	CIS	200	x	x	x	x	650	S			2150	F	OMD	
1071	RB	37		R		20		x		x		R		20		x		x								
1072	RB	37		F	CIS			x	x			F	CIS			x	x									
1073	RB	37									1500	S		200	x	x		x	x	F	OMD					
1074	RB	37										R		20		x		x								
1075	RB	37										S				x										
1076	RB	37	950	F	DID		x	x	x		x	S			x	x			x	F	OMD		x	x	x	
1077	RB	37	450	F	CID		x	x	x		x	F	CIS		x	S			x	B	OMD	125	x	F	OMD	
1078	RB	37																		S						
1079	RB	37	400	F	CID		x	x	x		x	F	CIS		x	S	x		x	B	OMD	125	x	F	OMD	
1080	RB	37																			S					
1081	RB	37	475	F	MID	125	x	x	x	x	x	x	x	x	x	S		200	x	F	OMD		x	x	x	
1082	RB	37		R		20		x		x		x		x		R		20								
1083	RB	37		F	CID			x	x			x	x			S										
1084			4925																							
1085	LB	37	1500	F	CID		x	x	x		x	x	x		x	x	x		x	B	CID	150	x	F	OMD	
1086	LB	37																		S						
1087	LB	37	225	F	CID	275	x	x	x	x	x	F	CIS	275	x	S			x	F	OMD		x	x	x	
1088	LB	37		R		30		x		x		x		x		x		x								
1089	LB	37	3650	F	MID		x	x	x		x	F	MIS		x	S			x	F	OMD		x	x	x	
1090			5375																							
1091	RB	38	2200	F	DID		x	x	x		x	x	x		x	S			x	F	OMD		x	x	x	
1092	RB	38	350	F	CID	200	x	x	x	x	x	x	x	x	x	S		200	x	F	OMD		x	x	x	
1093	RB	38		R		20		x		x		x		x		R		20								
1094	RB	38		F	CID			x	x			x	x			S										
1095	RB	38	175	F	CID		x	x	x		x	x	x		x	F	CIS		x	x	x		x	F	OMD	
1096	RB	38	1475	F	DID	275	x	x	x	x	x	F	DIS		x	S			x	F	CIS		x	F	OMD	
1097	RB	38		R				x																		
1098	RB	38	475	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	F	OMD	
1099	RB	38		F	CIS			x	x			x	x			x	x			x	x					
1100	RB	38	300	B	MMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1101	RB	38		R		30		x		x		x		x		x		x		x		x		x		x
1102	RB	38		P		50		x		x		x		x		x		x		x		x		x		x
1103	RB	38		R		20		x		x		x		x		x		x		x		x		x		x
1104	RB	38		P				x				x				x				x				x		
1105	RB	38	500	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1106	RB	38		R		30		x		x		x		x		x		x		x		x		x		x
1107	RB	38		P		50		x		x		x		x		x		x		x		x		x		x
1108	RB	38		R		20		x		x		x		x		x		x		x		x		x		x
1109	RB	38		P				x				x				x				x				x		
1110	RB	38	800	B	MMD	75	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MIS	100	x	x	x	x
1111	RB	38		F	CID			x	x			x	x			F	CIS			S				x		
1112			6275																							
1113	LB	38	1300	F	OMD	125	x	x	x	x	x	F	CID	125	x	x	x	x	200	S		125	1300	F	CIS	
1114	LB	38		R		30		x		x		x		x		x		x		R		30				
1115	LB	38		F	OMD			x	x			F	CID			x	x			F	CIS					
1116	LB	38																	1100	F	CIS	125				
1117	LB	38																		R		30				
1118	LB	38																		F	CIS					
1119	LB	38	1700	F	CID		x	x	x		x	x	x		x	S			x	F	OMD		x	x	x	
1120	LB	38	700	F	DMD		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x	
1121	LB	38	350	F	DMS		x	x	x		x	x	x		x	x	x		x	F	DID		x	x	x	
1122	LB	38	875	F	DMS	275	x	x	x	x	x	x	x	x	x	x	x	x	500	B	DMD	75	x	x	x	x
1123	LB	38		R		30		x		x		x		x		x		x		P				x		
1124	LB	38																	350	F	MIS		x	x	x	
1125	LB	38	300	P		275	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x
1126	LB	38		R		30		x		x		x		x		x		x		x		x		x		x
1127	LB	38	850	B	DMD	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	P		
1128	LB	38		P		100		x		x		x		x		x		x		P						
1129	LB	38		R		30		x		x		x		x		x		x								
1130	LB	38		P				x				x				x										
1131			6075																							
1132	RB	39	525	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1133	RB	39		P				x				x				x				x				x		
1134	RB	39	600	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MMD	
1135	RB	39		L		50		x		x		P		50		x		x		x		x				
1136	RB	39		R		30		x		x		x		x		x		x		x		x				
1137	RB	39		P				x				x				x				x						
1138	RB	39	700	B	MMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1139	RB	39		L		50		x		x		x		x		x		x		P		50		x		x
1140	RB	39		R		30		x		x		x		x		x		x		x		x		x		x
1141	RB	39		F	OMS			x	x			x	x			x	x			P				x		
1142	RB	39	1650	F	OMD		x	x	x		1000	F	OMD		x	x	x		x	x	x		x	x	x	
1143	RB	39									650	B	MMD	100	x	x	x	x	x	x	x	x	x	x	x	x
1144	RB	39										P				x				x				x		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1145	RB	39	700	F	DIS		250	P			x	x			x	x			700	B	DID	x	x	x	x	x
1146	RB	39					450	B	DID	100	x	x	x	x	x	x	x	x		P				x		
1147	RB	39						P				x				x										
1148	RB	39	425	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1149	RB	39		P				x				x				x				x				x		
1150			4600																							
1151	LB	39	700	B	DMD	50	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1152	LB	39		P		225		x		x		x		x		x		x		P				x		
1153	LB	39		R		30		x		x		x		x		x		x								
1154	LB	39	850	B	DMD	275	x	x	x	x	x	x	x	x	x	x	x	x	x	B	MIS		x	x	x	
1155	LB	39		R				x				x				x										
1156	LB	39	250	B	OMD	100	x	x	x	x	x	x	x	x	x	x	x	x	x	F	CIS		x	x	x	
1157	LB	39		R		20		x		x		x		x		x		x								
1158	LB	39		P				x				x				F	CIS									
1159	LB	39	1750	F	OMD		x	x	x		1100	F	CMS		1750	F	CIS		x	x	x		1000	B	CIS	
1160	LB	39									650	F	OMD										750	B	CIS	100
1161	LB	39																						P		
1162	LB	39	175	S			x	F	MIS		x	x	x		x	P			x	x			x	x		
1163			3725																							
1164	RB	40	750	F	OMD		x	x	x		x	x	x		x	F	CID		x	S		200	x	F	OMD	
1165	RB	40																		F	CID					
1166	RB	40	3350	B	MMD	150	x	x	x	x	x	F	MMD		x	x	x		x	x	x		x	x	x	
1167	RB	40		F	CID			S																		
1168			4100																							
1169	LB	40	2550	F	MMD		x	x	x		1550	F	MIS		2550	F	MIS		x	S			x	F	OMD	
1170	LB	40									1000	F	OMD													
1171			2550																							
1172	RB	41	1200	F	CIS		x	x	x		x	S			x	F	CID		x	x	x		x	x	x	
1173			1200																							
1174	LB	41	1500	B	DMD	175	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	F	OMD	
1175	LB	41		R		30		x		x		x		x		x		x		x		x				
1176	LB	41		F	CID			x	x			F	CIS			x	x			S						
1177			1500																							
1178	RB	42	200	S			x	x			x	x			x	x			x	F	OMD		x	x	x	
1179	RB	42	1300	F	DIS		x	x	x		400	B	MIS	100	1300	F	MMD		x	x	x		x	x	x	
1180	RB	42										S														
1181	RB	42									900	S														
1182	RB	42	1050	F	CIS		300	S			1050	S			x	F	OMD		x	x	x		x	x	x	
1183	RB	42					750	B	CIS	75																
1184	RB	42						S																		
1185			2550																							
1186	LB	42	2700	F	CID		x	x	x		x	F	CIS		x	x	x		x	S			x	F	OMD	
1187			2700																							

Table A-7: 1993 Cross Section Data

Horizontal (X) and vertical (Y) coordinates are given for cross sections in two reaches: RM 3.3 -RM 4.8 and RM 31.1 -RM 33.6. Elevations are relative to 1929 NGVD and were field-referenced to benchmarks maintained by Thurston County. Cross sections were surveyed in September and October, 1993.

Cross sections were located at approximate sites of cross sections surveyed in 1977 by the U.S. Geological Survey for a Federal Emergency Management Agency (FEMA) flood study. Complete cross section descriptions, cross section benchmarks, and sketches are available in copies of 1993 field notes, on file at the Squaxin Island Tribe Natural Resources Department.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	TUM93	TUM93	A93X	A93Y	B93X	B93Y	C93X	C93Y	D93X	D93Y	E93X	E93Y	F93X	F93Y	G93X	G93Y
2																
3	0.0	91.4	0.0	94.8	0.0	99.2	0.0	100.2	0.0	103.3	0.0	101.8	0.0	102.3	0.0	104.6
4	18.0	90.3	7.0	94.1	2.0	98.8	2.0	99.9	15.0	102.8	2.0	101.8	10.0	101.4	1.0	104.0
5	19.4	89.9	10.0	93.4	4.0	96.5	4.0	98.1	32.5	101.5	4.2	101.5	18.0	102.6	3.0	99.9
6	20.4	87.9	12.2	92.0	9.0	94.2	6.0	94.5	36.0	102.4	6.2	100.0	27.0	100.5	5.3	98.5
7	27.2	86.4	18.0	90.3	11.7	92.7	8.6	92.9	38.2	101.6	8.8	99.6	30.0	99.9	10.0	96.2
8	38.0	84.5	28.0	90.0	21.0	92.0	11.4	92.1	41.0	99.4	15.0	95.5	32.0	98.3	14.0	94.4
9	43.0	84.6	39.0	89.5	31.0	91.2	23.0	90.8	43.0	96.2	16.2	94.1	35.0	96.8	18.0	95.6
10	56.0	83.7	44.0	90.0	43.0	89.4	33.0	89.7	48.0	93.9	19.5	92.2	37.0	95.2	20.2	95.4
11	68.0	83.6	48.0	90.8	48.0	89.1	41.0	88.6	53.0	93.2	22.0	91.4	44.0	94.9	32.0	96.7
12	89.0	83.8	52.5	92.0	61.0	92.8	47.0	90.5	63.0	92.6	28.0	90.8	49.0	94.2	46.7	98.5
13	107.0	84.5	56.3	95.4	67.0	100.0	53.5	92.9	73.0	92.4	32.5	90.3	63.0	91.7	52.2	100.5
14	127.0	84.4	58.0	96.6	71.9	101.3	60.0	97.5	83.0	92.8	39.5	90.1	67.0	91.8	60.0	102.5
15	139.0	82.6	60.0	98.4			62.0	100.0	93.0	93.4	43.0	91.3	71.0	92.0	72.0	102.0
16	144.0	81.0	60.9	98.5			63.5	100.2	101.6	93.9	49.0	92.7	77.0	93.9	88.0	103.2
17	148.0	81.1							104.0	95.9	52.3	94.0	80.5	95.2	100.0	102.6
18	149.5	86.5							106.0	96.8	56.0	96.3	84.0	96.8	150.0	104.2
19	155.0	89.9							110.2	97.1	58.0	99.6	87.0	100.4	200.0	105.3
20	159.0	92.2									64.0	100.9	89.0	102.2	250.0	106.2
21	163.0	92.8									66.2	102.3	92.7	103.6		101.2
22	166.0	93.2									120.0	104.6	143.0	104.8		

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1	H93X	H93Y	I93X	I93Y	K93X	K93Y	L93X	L93Y	N93X	N93Y	M93X	M93Y	O93X	O93Y	Q93X	Q93Y
2																
3	0.0	104.6	0.0	106.0	0.0	112.3	0.0	109.7	0.0	111.9	0.0	110.4	0.0	114.5	0.0	114.4
4	10.0	103.4	11.4	105.0	27.0	111.3	12.7	108.9	4.8	111.4	6.2	109.1	40.0	114.7	36.0	112.7
5	12.5	102.5	15.0	100.9	37.0	108.4	18.4	107.7	6.1	111.1	13.1	110.3	75.9	114.1	50.0	110.8
6	16.0	101.0	15.0	100.2	48.7	104.5	20.0	106.2	9.6	107.1	19.9	108.5	85.0	113.9	57.0	111.0
7	17.8	99.6	19.0	99.3	54.0	102.6	21.4	105.3	11.1	105.6	24.0	108.0	94.5	110.8	59.0	108.2
8	20.0	99.5	23.0	99.7	64.5	103.6	28.0	102.6	16.5	104.3	26.6	105.3	97.0	108.8	60.1	107.3
9	21.5	99.7	28.0	99.4	75.0	104.1	34.0	102.5	26.0	104.5	36.2	104.7	102.2	105.7	67.0	107.2
10	29.0	99.8	38.0	100.1	85.0	104.5	43.0	102.8	35.0	104.4	46.0	104.2	103.0	104.7	77.0	106.0
11	35.0	99.5	48.0	99.7	95.0	104.6	53.0	103.1	45.0	104.2	56.0	103.4	107.1	102.4	88.0	104.1
12	45.0	99.2	58.0	99.6	105.0	104.7	63.0	103.1	55.0	104.4	65.0	103.1	112.0	102.9	89.5	103.8
13	55.0	98.7	63.0	100.1	113.8	105.0	73.0	102.9	62.0	104.4	75.0	102.7	123.0	103.4	91.5	103.7
14	62.0	97.9	67.2	101.0	122.0	106.1	83.5	102.9	64.9	104.0	81.0	103.0	135.0	104.4	98.0	105.6
15	66.0	97.7	70.0	102.2	129.1	106.6	93.0	102.7	67.0	104.0	86.3	105.4	149.4	105.7	101.5	107.2
16	70.0	97.9	90.0	103.8			97.0	103.2	71.0	104.6	91.1	109.2	154.4	106.3	105.0	110.1
17	74.5	99.6	103.7	105.7			99.0	104.2	72.8	105.6	94.0	110.1	158.8	108.1	111.0	113.2
18	76.8	103.9					99.0	105.3	75.9	106.4	98.4	113.2	161.8	110.4	115.0	114.6
19	83.0	105.6					101.0	107.2	80.1	107.9	102.0	114.1	170.4	112.4	118.0	115.4
20	88.0	104.5					105.0	108.5	90.1	111.6	106.7	114.0	200.0	112.5	121.3	115.7
21	91.5	107.4					110.5	110.0								
22																

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	JD93X	JD93Y	JE93X	JE93Y	JF93X	JF93Y	JG93X	JG93Y	JH93X	JH93Y	JI93X	JI93Y	JJ93X	JJ93Y	JK93X	JK93Y	JL93X	JL93Y	JM93X	JM93Y	JO93X	JO93Y
2																						
3	0.0	450.8	0.0	452.3	44.0	452.3	0.0	456.1	0.0	456.1	0.0	459.6	0.0	461.1	0.0	465.5	0.0	465.7	0.0	461.3	0.0	471.3
4	29.5	450.5	20.0	451.2	58.0	451.0	16.0	455.8	13.5	455.9	14.9	459.2	20.0	461.3	46.0	464.7	26.2	466.4	5.0	460.8	15.0	466.4
5	50.0	448.3	27.7	449.7	84.0	448.9	26.1	455.5	18.0	454.9	18.5	458.3	29.5	460.7	50.0	462.9	28.0	461.1	10.0	456.8	25.0	462.2
6	60.3	447.1	30.2	447.4	98.0	447.0	37.0	455.7	24.0	452.6	25.0	454.8	35.0	456.8	56.7	459.0	32.0	458.7	13.4	455.3	32.0	460.0
7	65.0	444.9	32.0	445.1	107.5	444.9	61.0	451.2	28.0	449.2	31.7	449.3	39.0	454.9	59.0	453.8	39.0	456.5	15.4	454.3	34.5	458.0
8	80.0	443.3	35.0	443.3	120.0	442.3	68.0	452.2	34.0	447.7	35.4	447.0	45.0	451.4	66.5	451.9	45.2	454.2	19.5	452.4	41.0	457.6
9	100.0	442.4	41.7	442.3	123.0	441.6	71.5	452.0	43.0	447.7	44.0	447.9	48.8	449.5	95.5	451.5	63.0	452.8	31.1	453.7	43.0	457.5
10	109.0	441.7	47.5	442.2	134.8	442.1	74.5	452.0	53.0	448.2	54.0	448.5	55.5	449.1	101.3	450.7	68.0	452.9	41.0	453.1	53.0	457.0
11	116.0	441.7	60.0	443.0	143.0	444.8	80.0	448.6	63.0	448.1	64.0	449.0	80.0	449.2	115.0	450.1	87.0	452.9	51.0	450.7	63.0	457.1
12	122.0	442.3	75.0	443.5	156.0	451.0	89.0	446.0	73.0	448.4	74.0	449.2	92.0	449.2	126.0	450.0	96.0	452.9	55.0	449.9	85.0	457.3
13	128.0	442.8	89.0	443.8	163.0	463.6	109.0	448.1	83.0	448.5	84.0	449.3	103.0	448.9	134.8	450.8	108.0	453.4	68.0	449.5	101.0	457.8
14	133.5	444.9	96.0	445.1			129.0	448.0	94.5	449.2	90.8	449.4	108.0	449.5	141.5	453.5	115.8	454.2	88.8	452.7	121.2	459.7
15	138.0	448.1	97.0	447.5			154.0	448.8	96.5	451.6	95.0	454.2	112.3	449.9	144.6	457.1	131.0	456.1	74.0	454.2	132.0	461.5
16	124.0	450.2	102.0	449.3			162.0	451.8	105.0	454.0	99.0	458.3	113.3	452.7	150.6	461.3	143.0	457.3	81.5	457.7	187.0	470.0
17	151.3	451.1	118.5	451.4			179.0	453.3	109.5	454.6	103.0	459.3	118.5	457.5	184.6	461.7	157.1	459.4	86.5	460.3		
18	158.2	451.4	144.0	452.1			205.0	456.0	166.5	455.9	122.0	460.2	140.0	460.4			182.0	460.0	91.0	466.1		
19	200.0	451.1															192.2	462.4	105.5	469.5		
20																	222.2	462.0	124.0	469.6		

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	JQ93X	JQ93Y	JR93X	JR93Y	JS93X	JS93Y	JT93X	JT93Y	JV93X	JV93Y	JW93X	JW93Y	JX93X	JX93Y	JY93X	JY93Y
2																
3	0.0	467.4	0.0	464.9	0.0	469.3	0.0	471.5	0.0	476.1	5.0	481.8	0.0	485.6	0.0	481.1
4	18.0	466.4	8.0	464.8	14.0	468.4	10.0	470.9	12.2	474.2	25.0	473.7	12.5	480.8	25.0	480.7
5	33.0	466.4	17.0	469.2	20.0	471.0	16.0	469.3	18.5	471.1	29.0	471.9	16.0	476.0	55.0	480.4
6	38.0	465.2	32.0	469.1	29.0	467.2	19.0	468.2	21.0	470.3	31.0	470.3	20.8	473.9	76.0	481.4
7	44.6	461.2	30.5	471.2	33.5	465.2	34.5	467.4	22.3	468.5	37.0	468.8	21.8	472.0	90.0	477.9
8	49.5	462.9	45.0	466.8	33.5	460.8	50.0	467.0	28.0	467.2	45.2	470.4	24.5	470.4	134.6	475.2
9	52.0	461.8			40.0	461.6	65.0	466.9	34.0	468.6	52.0	471.2	31.5	469.2	142.0	474.5
10	62.0	460.9	59.0	464.2	49.0	463.9	80.0	467.1	44.0	469.9	58.5	471.1	41.0	471.4	152.0	473.8
11	72.0	461.1	69.0	464.1	62.0	464.5	90.0	467.1	63.0	468.7	74.0	470.3	54.0	472.7	161.5	473.2
12	82.0	461.5	88.0	464.3	78.5	465.3	97.5	467.5	74.0	467.8	83.0	469.5	70.2	474.0	170.0	473.3
13	92.0	461.7	107.0	464.0	80.0	465.5	102.0	469.2	88.0	466.9	93.0	469.9	74.4	474.6	176.0	474.5
14	110.5	462.8	125.0	464.8	87.5	468.2	107.3	471.1	93.0	466.8	101.7	470.9	98.0	476.3	181.0	476.2
15	134.0	464.0	143.7	465.4	99.0	469.8	110.5	471.3	98.0	466.7	117.0	475.6	116.5	474.6	184.3	480.3
16	156.0	466.5	152.0	471.5	164.0	471.1	133.0	472.8	103.0	470.6	200.0	475.7	124.5	478.7	200.0	480.9
17	200.0	465.7	159.0	466.8					106.2	471.4			135.0	478.7	220.0	481.2
18			200.0	468.2					126.7	473.8			152.0	480.6		
19									178.0	473.5			173.7	481.2		
20																

Table A-8: Landslide Inventory

Landslides 200 cubic meters or larger in volume that entered stream channels in the upper Deschutes River watershed. Landslide numbers use the system adopted in the Standard Methodology for Conducting Watershed Analysis Under Chapter 222-22 WAC (Version 2.0) ***(Washington Forest Practices Board, 1993).*** Data is from Weyerhaeuser Co. ***(1993)*** Sullivan and others ***(1987)*** and Toth ***(1991a)***.

Table 10-8

	A	B	C	D	E	F	G	H
1	NUMBER (a)	DRAINAGE (b)	YEAR	RM (c)	TRIB RM	DELIV	VOLUME	CAUSE
2					(d)	(e)	(CM)	(f)
3	15/2E-11J1	Fall Creek	1990	35.3	0.7-0.4	2		R
4	15/2E-13F1	RM 35.4 LB	1990	35.4	1.3-1.0	2		R
5	15/3E-17P1	Huckleberry Creek	54-66	38.2	1.4-0.4	2		<12
6	15/3E-29C1	Huckleberry Creek	1990	38.2	2.7-0.3	2		R
7	15/3E-30Q1	Mitchell Creek	66-72	38.2	3.3-0.3	2		R
8	15/3E-32E1	Mitchell Creek	66-72	38.2	3.7-3.5	2		R
9	15/4E-20L1	Little Deschutes R. trib.	1990	42.5	4.5	2		
10	15/3E-26H1	RM 45.5 LB	1990	45.5	0.5-0.1	2		R
11	15/3E-35D1	Lincoln Creek	66-72	46	1.3	2		<6
12	15/3E-35E2	Lincoln Creek	1990	46	1.5	2		<22
13	15/3E-34H1	Lincoln Creek	1990	46	1.7	2		R
14	15/3E-34J1	Lincoln Creek	1990	46	2	2		<22
15	15/3E-34Q1	Lincoln Creek	1990	46	2.2	2		<22
16	15/3E-34N1	Lincoln Creek	1990	46	2.6	2		6
17	15/3E-35H1	Lincoln Creek	1978	46	0.7-0.5	2		R
18	15/3E-35E1	Lincoln Creek	66-72	46	1.4-0.5	2		<6
19	15/4E-31L1	Lewis Creek	1990	46.5	1	2		6
20	15/4E-31K1	Lewis Creek	1990	46.5	1.2	2		6
21	15/3E-36J1	Lewis Creek	66-72	46.5	0.4-0.8	2		R
22	14/4E-6G1	Lewis Creek	1990	46.5	2.0-0.6	2		R
23	14/3E-1D1	RM 47.1 LB	1982	47.1	0.4-0.0	1	4700	<16
24	14/3E-1C1	RM 47.3 LB	1990	47.3	0	1	400	0
25	14/3E-1A1	Buck Creek	87/90	47.4	0.5-0.3	1	500	R
26	14/3E-1J1	Buck Creek	1982	47.4	0.8-0.0	1	2000	<16
27	14/3E-1M1	RM 47.8 LB	1986	47.8	0.2-0.0	1	5000	R
28	14/3E-1P2	RM 47.9 RB	1990	47.9	0.4	2		R
29	14/3E-1P1	RM 47.9 RB	1982	47.9	0.4-0.0	1	200	R
30	14/3E-2P1	Thorn Creek	1990	48	0.8	2		R
31	14/3E-11D1	WF Deschutes River	1990	48	1.3	2		0
32	14/3E-12E1	Ware Creek	1982	48.6	0.1-0.0	1	1000	<16
33	14/3E-12M1	Ware Creek	1982	48.6	0.2-0.0	1	6600	R
34	14/3E-12K1	Ware Creek	1982	48.6	0.5-0.0	1	3000	<16
35	14/3E-12Q1	Ware Creek	1990	48.6	0.8-0.0	1	5000	0
36	14/3E-11J1	RM 48.8 RB	1974	48.8	0	1	700	R
37	14/3E-12N1	Hard Creek	1978	49	0.3-0.0	1	700	R
38	14/3E-11Q1	RM 49.2 RB	1978	49.2	0.2-0.0	1	300	R
39	14/3E-14L1	Mine Creek	66-72	49.6	0.8-0.3	2		<6
40	14/3E-15K2	RM 50.5 RB	1990	50.5	0.3-0.0	1	700	R
41	14/3E-15K1	RM 50.6 RB	66-72	50.6	0.3-0.0	1	300	R
42			-					
43	*(a) Numbering system from Washington Forest Practice Board (1993).*							
44	(b) Stream of origin, or if debris flow or dam-break flood, stream of deposition.							
45	(c) Deschutes River Mile. (d) Tributary River Mile.							
46	(e) Delivery to Deschutes River: 1=NO, 2=YES.							
47	(f) (R): Road-related; (Number): Age of forest for non-road-related failures.							